Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

SEPTEMBER, 1954

TECHNOLOGY DEPARTMENT

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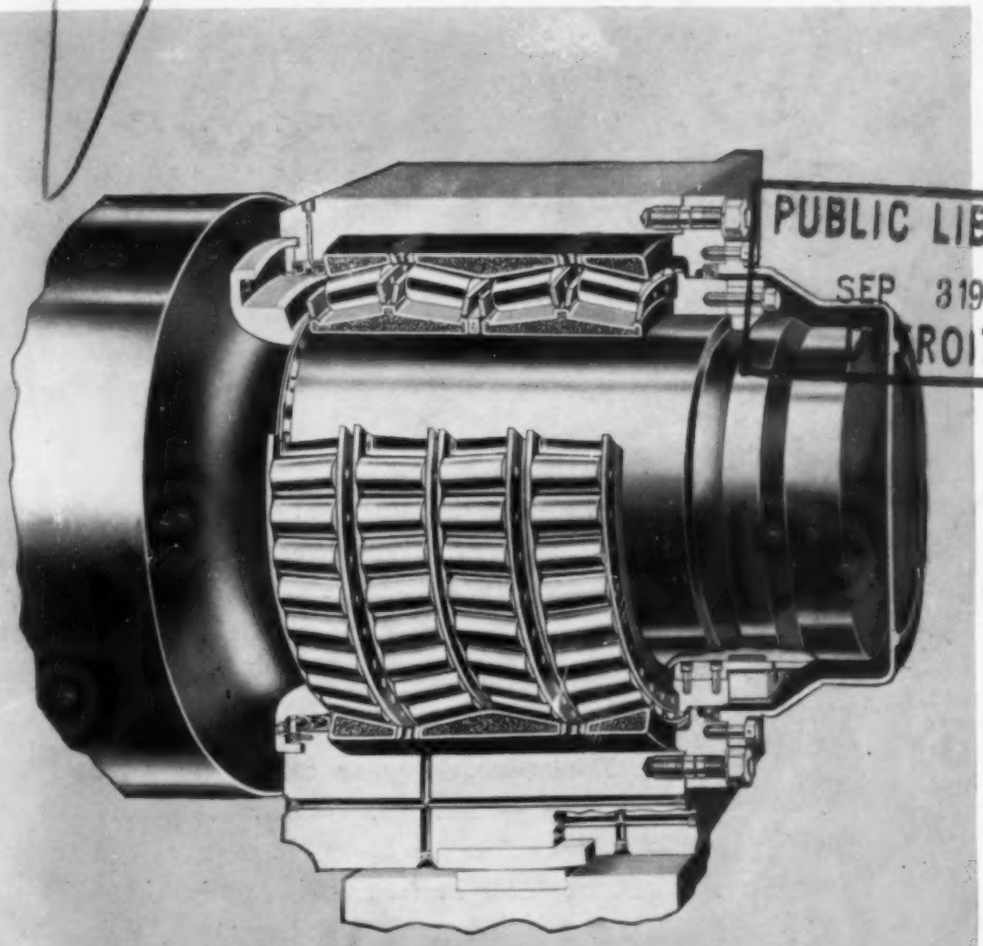
Why Allegheny Ludlum's improvement program features 130 TIMKEN® roll neck bearings



ALLEGHENY LUDLUM STEEL CORPORATION *mounts work and back up rolls on Timken tapered roller bearings to get less friction, longer life. Typical Timken roll neck bearing application is shown in cutaway.*

DOLLAR for dollar, Timken® roll neck bearings can't be beat—and mill records prove it. Actual cost figures show Timken bearing equipped mills operate at minimum bearing cost per ton of steel rolled! Allegheny Ludlum Steel Corporation has put 130 new Timken roll neck bearings on mills in the Brackenridge and Leechburg plants. It's part of their extensive program of improvements.

Timken bearings eliminate complicated lubrication systems, make roll changing easier and faster. Maintenance and repair time is cut.

The tapered design of Timken bearings lets them take both radial and thrust loads in any combination so that special thrust units are not required. And Timken bearings can take the heaviest mill loads. Line contact between rollers and races gives Timken bearings extra load-carrying capacity.

Mills accelerate more rapidly with Timken bearings because they lower starting resistance, reduce skidding and scuffing between work rolls and back up rolls. Over 50 years of bearing research and development have made Timken bearings first choice throughout industry. For more information about Timken roller bearing applications, write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN
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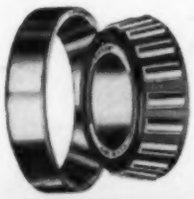
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭

BEARING TAKES RADIAL ↓ AND THRUST →◎← LOADS OR ANY COMBINATION ✳

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DETROIT

Lower Maintenance Costs, More Stable Resistance Values, Higher Current Capacities

Cutler-Hammer now offers a brand-new unbreakable mill-type resistor with design features that provide an all-welded current path, that stabilize resistance values, afford high current capacities, and resist corrosion and vibration.

The individual grids are punched from a chromium steel alloy and are mounted in an unique over-under arrangement to attain exceptionally efficient heat radiation which permits continuous current capacities up to 180 amperes per box. The low resistance coefficient of the grid alloy results in small resistance change despite grid temperature variation. Grid junctions are seam welded and terminal taps spot welded to insure a continuous current path and to eliminate grid contact troubles. Rugged steel and mica washers are used as grid spacers and insulators.

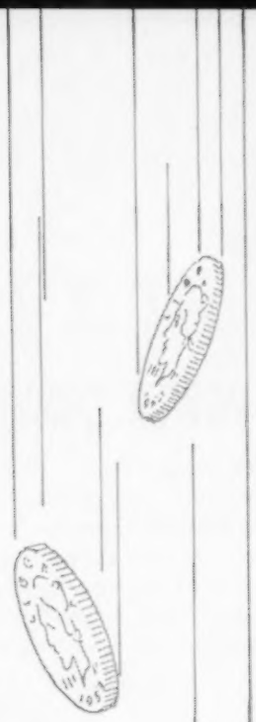
A radically new type of end plate and grid rod design affords "draw-out" replacement of the grid assembly without disturbing the end plates or other boxes in the resistor stack. This exclusive construction feature also compensates for thermal expansion of the individual grids.

These resistors are available in ratings from 1/10th to 10 ohms. Standard boxes come in 17", 22½" and 28" lengths. Terminals provide 10% resistance steps. All resistors are insulated for 600 volt service.

For lower maintenance costs, more stable resistance values, and higher current capacities *standardize on these new Cutler-Hammer Bulletin 11011 Unbreakable Resistors.* CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 31, No. 9



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good equipment brings production costs down

Every improvement in seamless tube mill equipment has been developed by the combined efforts of the steel industry and Aetna-Standard. That's one reason why Aetna-Standard builds more seamless tube mills than all companies combined. If you contemplate adding tube facilities or revamping existing equipment, call in Aetna-Standard. Such data as costs, rates of production, amortization, equipment details, will give you good information on which to base a decision. **Only from Aetna-Standard can you obtain this authoritative guidance.**

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"our first unit still satisfactory"

"rough treatment doesn't hurt it"

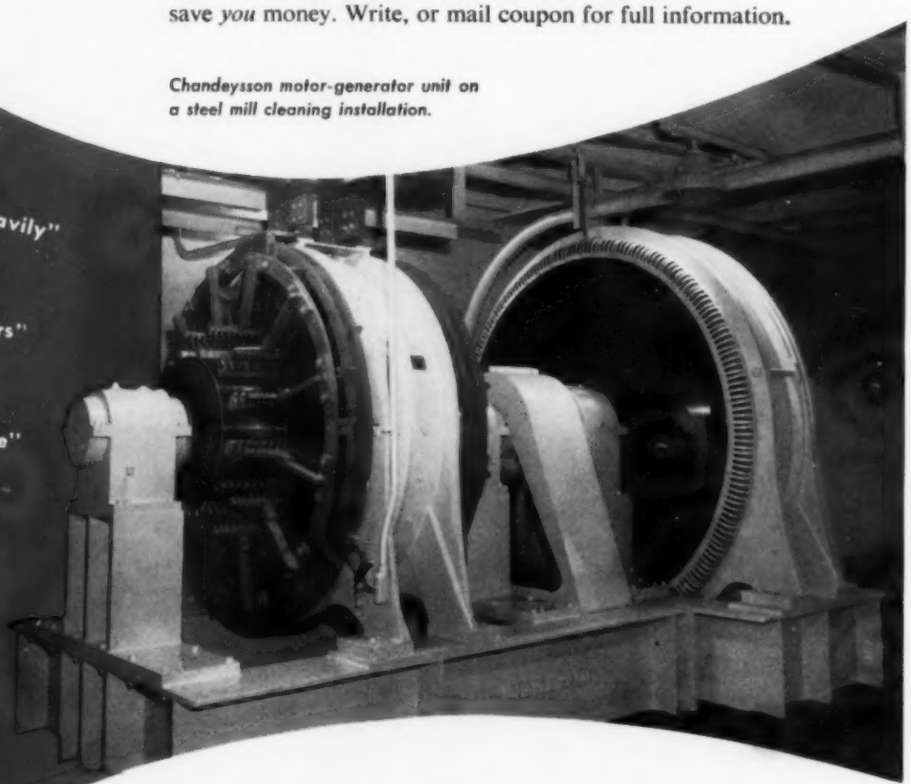
"48 years in service"

"nothing for maintenance"

"in 20 years bought only brushes"

"thoroughly sold on Chandeysson"

Chandeysson motor-generator unit on a steel mill cleaning installation.



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U S G Grade 135 Mill Motor Brush with Statite*

U S G Grade 223 Brush for DC crane motors with Statite*

U S G Grade 1658 Brush for tin line collector rolls

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*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

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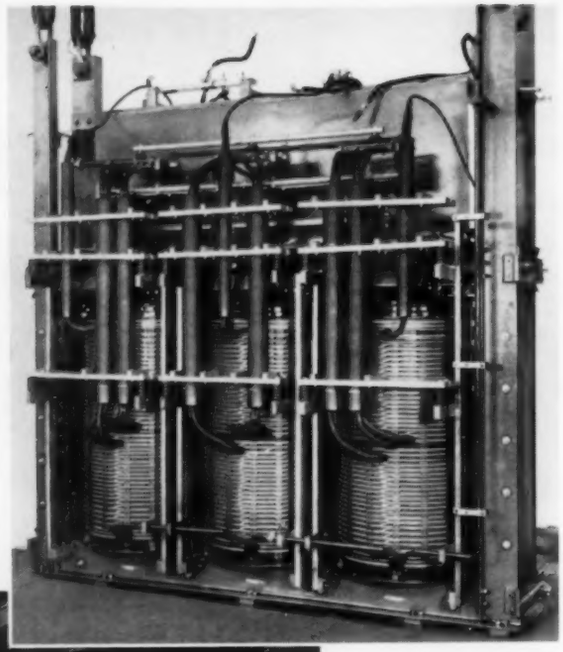
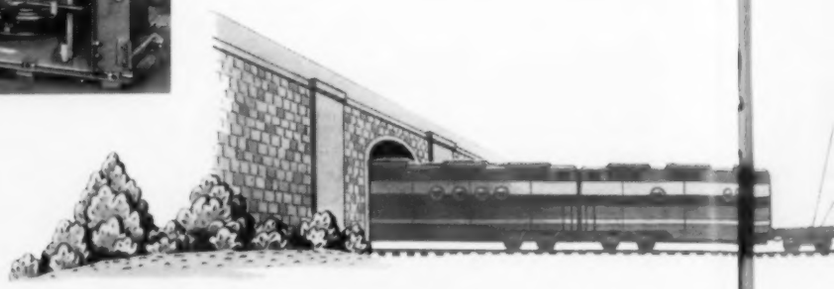
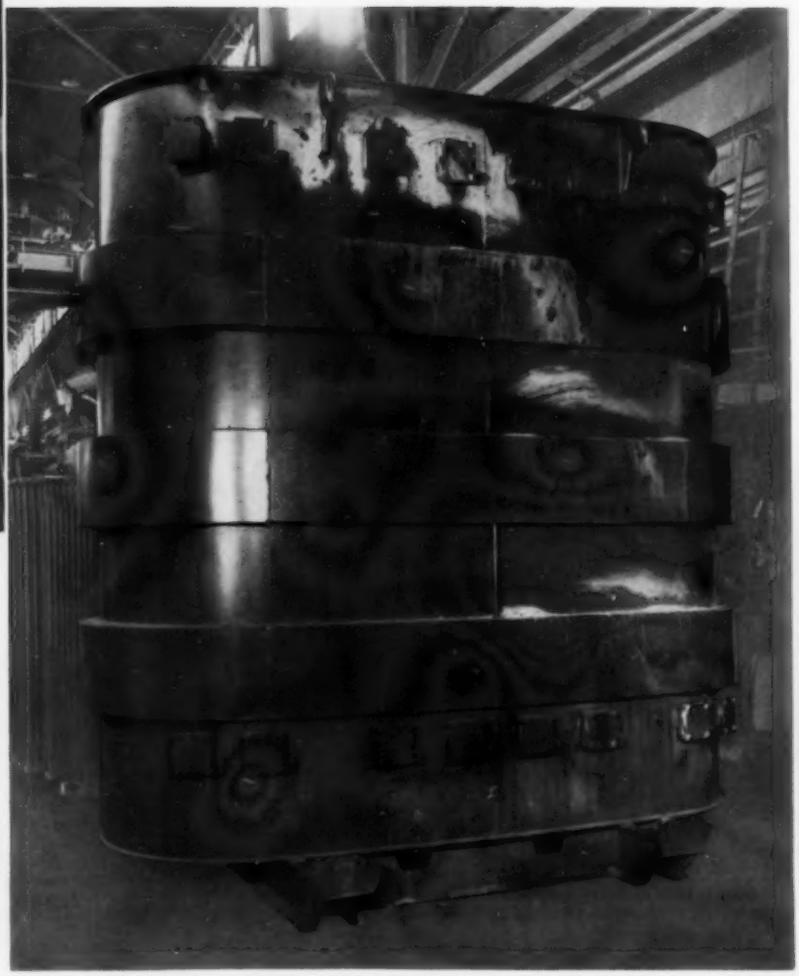


Electrical tests showed that no damage was done to the core and coils.





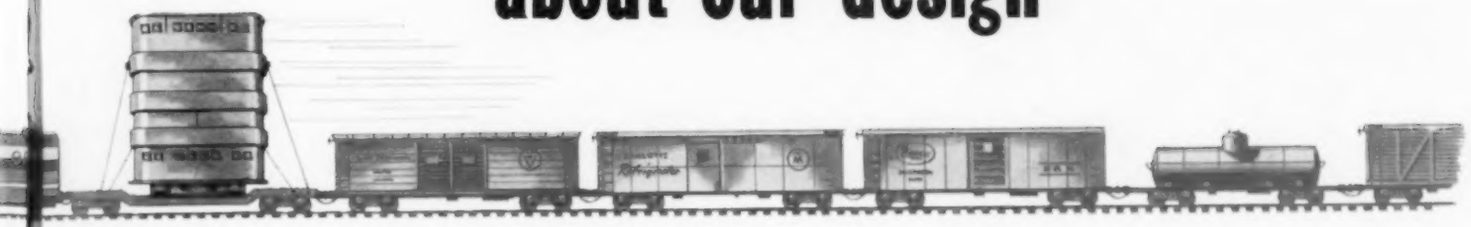
Inspecting engineer points out damaged base member.

Transformer tank withstood accident without damage.

Load ratio control compartment was bent — but controls were undamaged.

like Accidents,

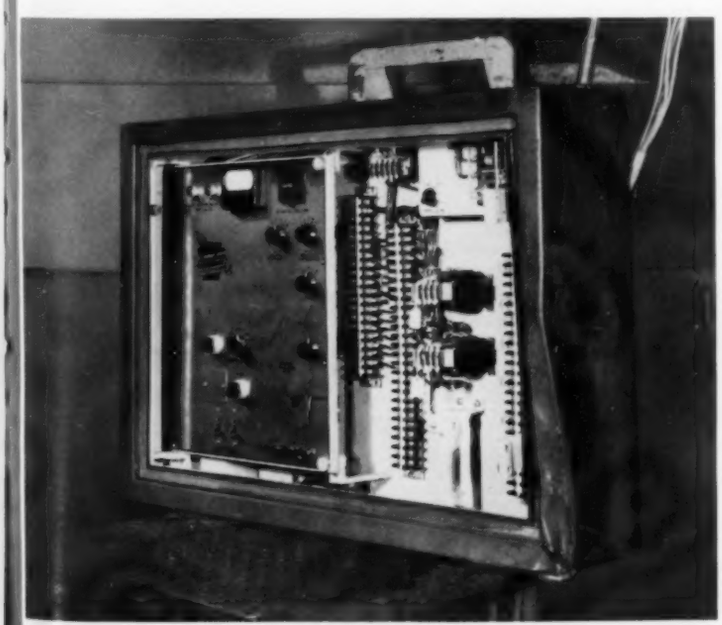
but...look what an accident showed us about our design



When the bridge is too low and the transformer traveling toward it is too tall, something is bound to happen when the two meet. And something did happen!

A depressed center car, carrying a Pennsylvania 7500 Kva Load Ratio Control Transformer, was switched from one track to another and coupled to the wrong train. Then it met up with the concrete bridge! After the dust cleared away, the transformer and car were found turned over on their sides.

When returned to our shop, the transformer was thoroughly inspected. Electrical tests showed that no damage had been done to the core and coils. Damage inside the transformer was negligible — a broken bushing lead and a few cracks in some wooden supports. *That's all!* The internal damage was slight *because* the core-and-coil assembly was rigidly supported and held by the core clamping frames — even when the transformer fell over on its side.



Externally, the load ratio control compartment was distorted, but the controls were undamaged. Two mounting panels of the underload tap changing switch were cracked. The front of the switching compartment was distorted, as was the nitrogen cabinet. Some of the transformer base members were bent and cut, and the portion of the cover that hit the bridge was dented.

That was the sum total of the damage. Repairs were made and complete electrical tests showed the transformer to be in excellent operating condition. It was shipped back to its destination and this time it stayed on the right track.

We believe the negligible damage that resulted from this accident is substantial proof of the extra mechanical strength built into all Pennsylvania Power Transformers.

PENNSYLVANIA TRANSFORMER COMPANY
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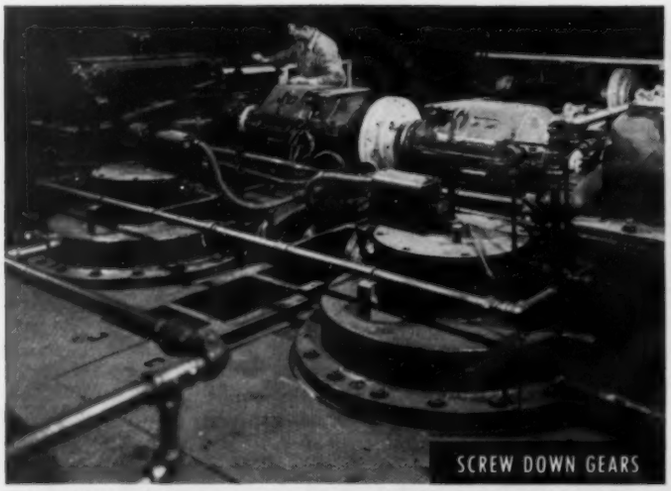

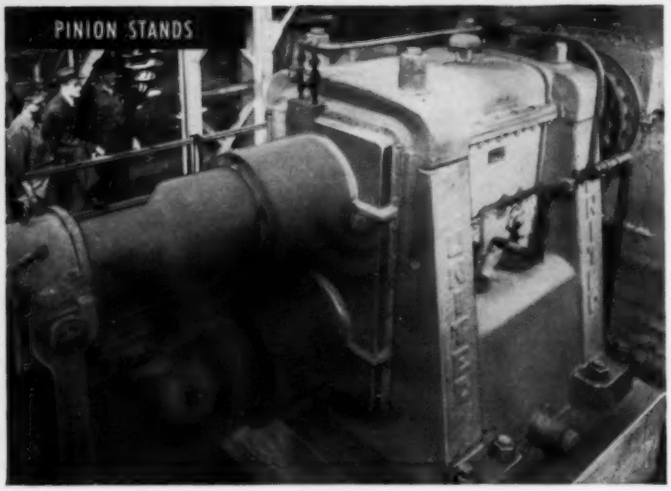

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This "plus protection" of Gulf E.P. Lubricants not only prevents excessive gear wear but insures freedom from rust, foaming, and other lubrication troubles.

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For more complete information, or for expert help on your gear drive lubrication problems, send the handy coupon.

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Gentlemen:

I would like further information on Gulf E.P. Lubricants:

- ☐ Please have a Gulf Sales Engineer call. ISE
- ☐ Please send me a copy of your pamphlet "Gulf E. P. Lubricants for Reduction Gear Drives."
- ☐ Please arrange to show a group in our plant the new Gulf Color Slide Film, "Gears and Their Lubrication."

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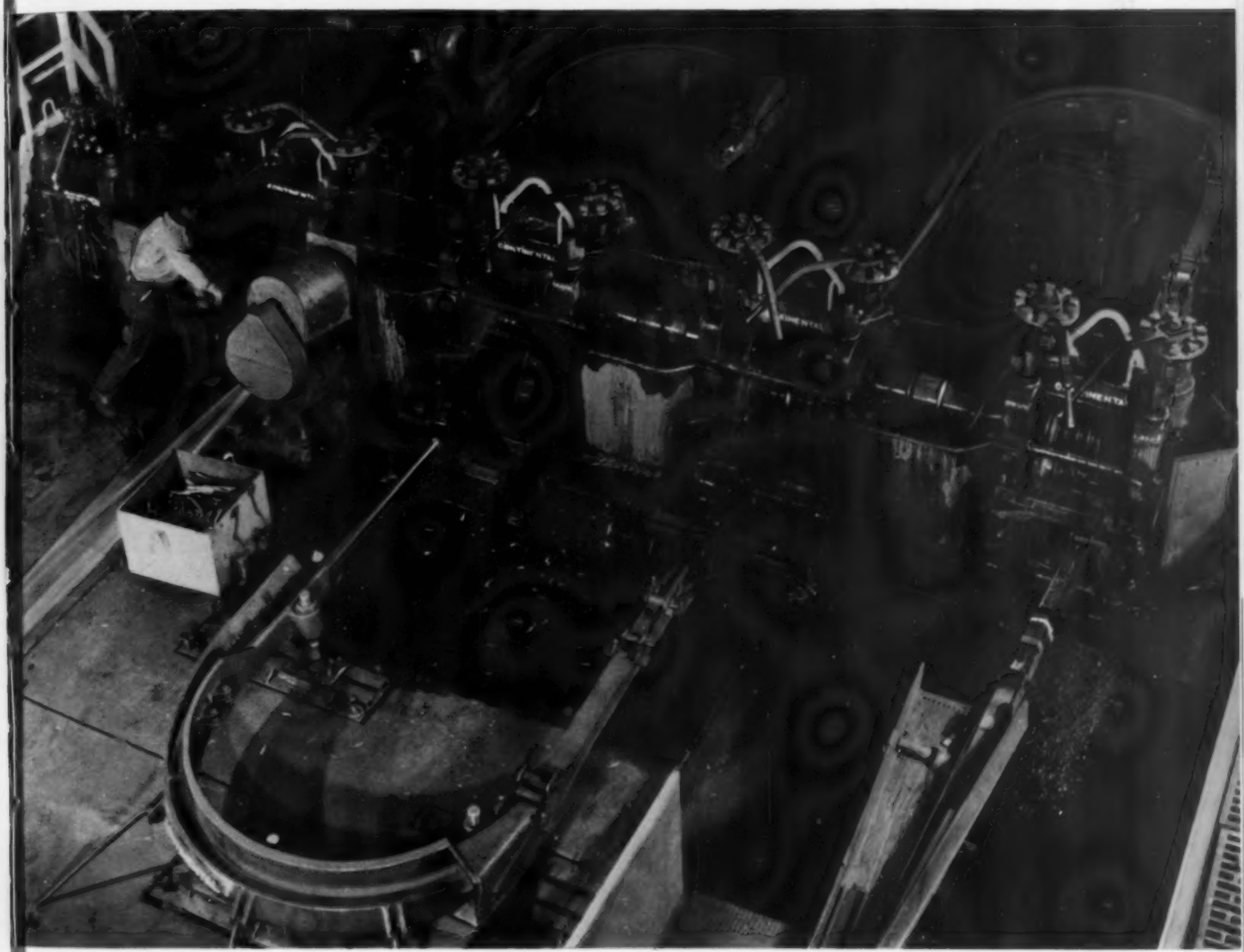
CONTINENTAL

10-INCH MERCHANT MILL



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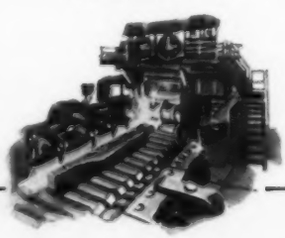

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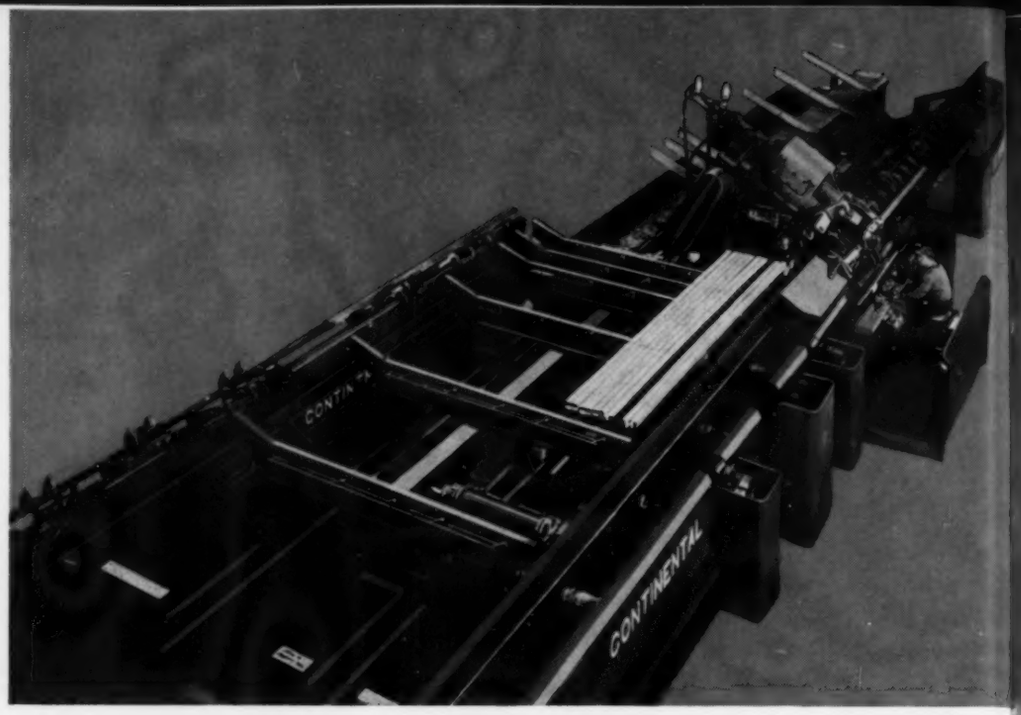

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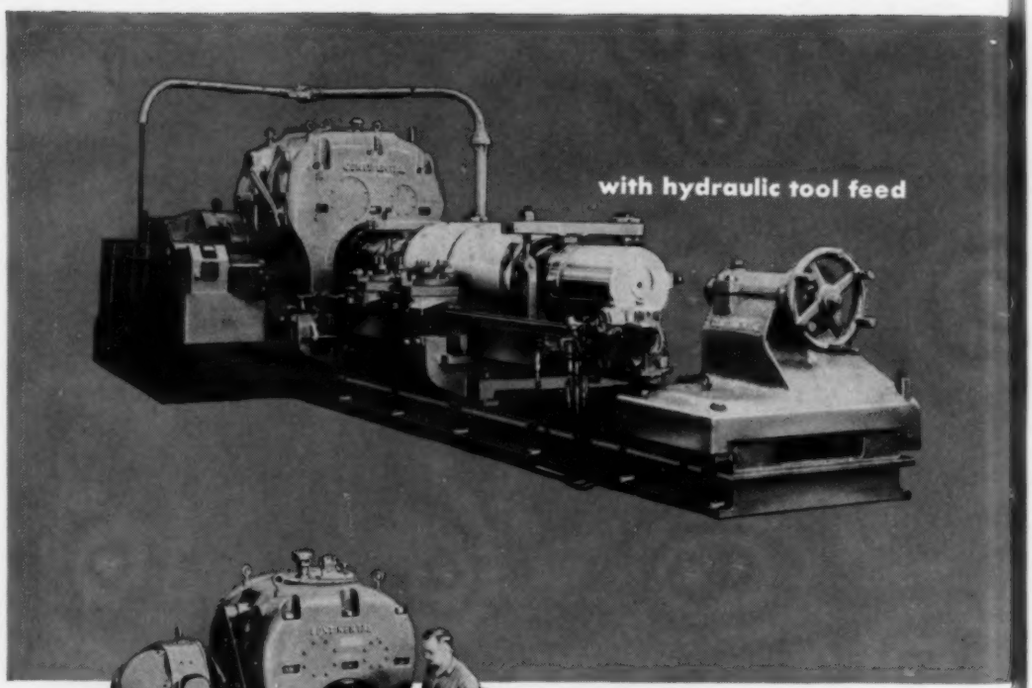
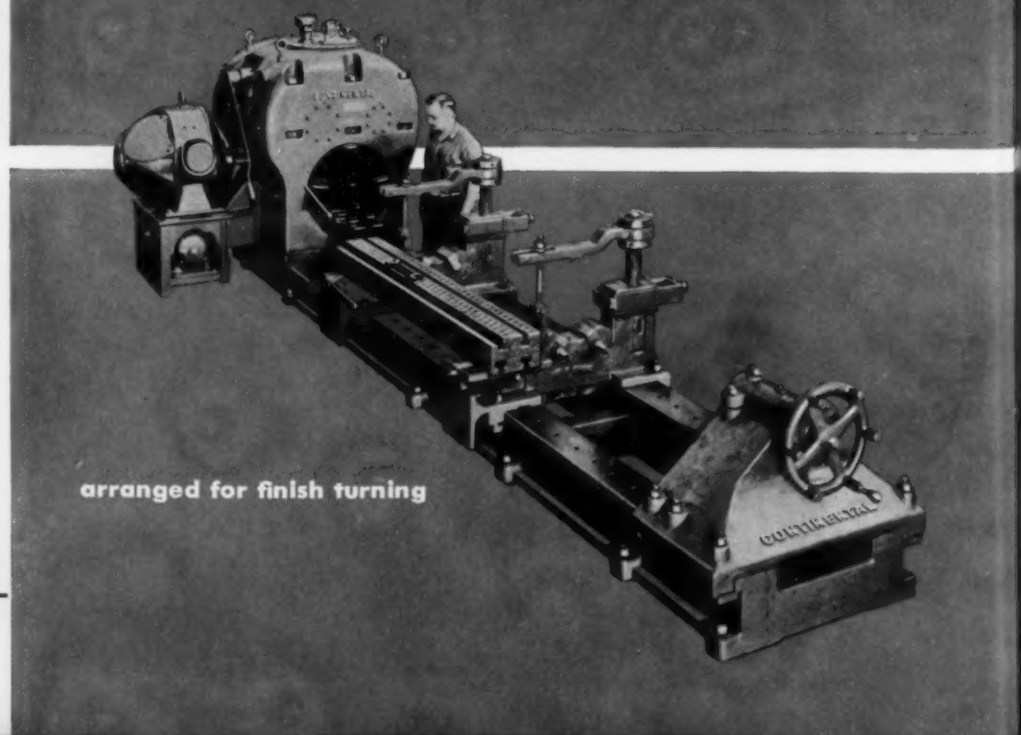

with hydraulic tool feed



arranged for finish turning

* * *

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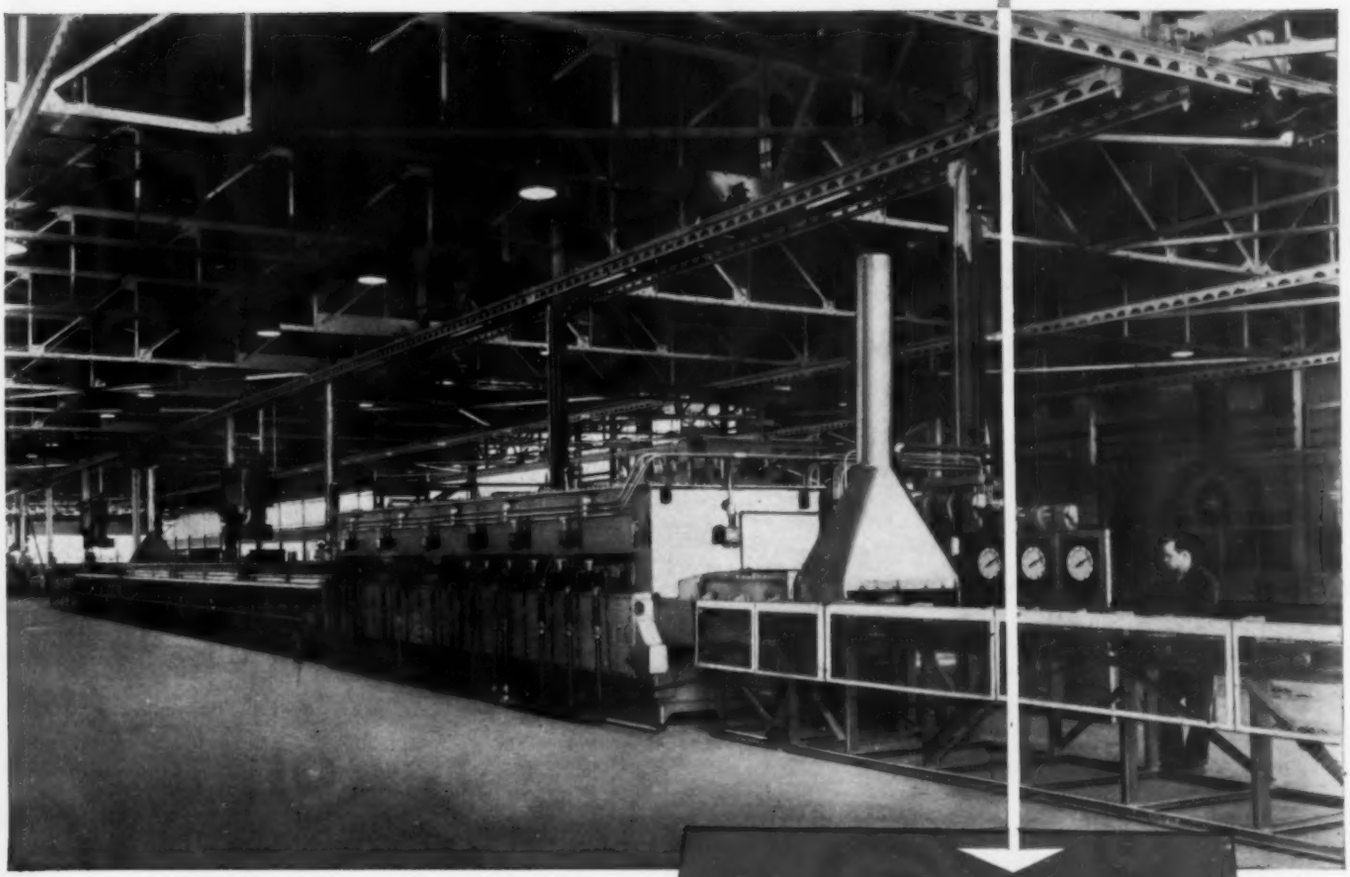

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Shown above:

Controlled Atmosphere Furnace
Radiant Tube, Gas-Fired
Capacity, 3,000# /hour
Alloy Tubing ⅛" O.D. to 2½" O.D.
Overall, 176 ft. long x 7'-6" wide

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DIGEST

A bimonthly publication of National Carbon Company, A Division of Union Carbide and Carbon Corporation. Written especially for electrical maintenance men as a service by America's best known brush manufacturer. Designed as a helpful guide . . . A handy reference on the subject of Brushes and Commutation.

No. 1
Good Machine Performance
Brush Commutator Teamwork

Correct selection and application of brushes . . .

. . . together with proper commutator care PAYS OFF . . . in improved machine performance, fewer maintenance headaches, less costly down time. Here is the first of a series of quick-reading articles in easy-to-keep pamphlet form to help you get better acquainted with the commutator and some of the every-day things you can do to keep it in tip-top shape. In this, and future issues we will cover timely topics that [illegible] your daily work—Tak-

and Set Brushes—and many more. We have been asked many times to put such information into condensed form . . . and today's high cost of machine replacement pinpoints the need now. The "National" Brush Digest brings you solid subject matter in a manner we hope you will find enjoyable . . . and profitable.

Good Machine Performance

There are a great many factors involved in good machine performance with question as to which are the most important. When machines are made many of these factors are built in as part of the design. We are choosing 6 elements which are closely associated with commutator and brush maintenance. Some of these trace back to qualities built in by the machine's manufacturer; others accrue from proper commutator maintenance and brush application once the machine has been placed in operation. In coming pamphlets we will dig in deeper detail into these 6 Elements of Good Performance. We will show you some of the things you can do to attain them in your own operation and thus enjoy the best possible performance from your machines. Meanwhile, let's sketch in these important elements.

The more your men know, the more they're worth . . . to *you.* Based on NATIONAL CARBON'S 70-year experience in brush theory and practice, this series of pamphlets is *specially edited for the operating man.* Installments are short, easy to read, clearly illustrated, hold his interest, provide a regular reminder of the company's interest in *him.* Saved for reference, these pamphlets are a handy source of information on many practical maintenance problems encountered in his work.

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A De Luxe edition of our 115-page treatise on brushes and commutation, each costing several dollars to print. This is a GIFT to you for helping distribute National Carbon's FREE Maintenance Course where it will do you – your company and your men – the most good.

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30 East 42nd Street — Room 1328 — New York 17, N. Y.

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I understand that this offer is made by your company as an industrial service and in no way obligates me or my company to National Carbon Company or to the use of its products. I am to receive the above series of pamphlets, plus a complete De Luxe Copy of "Treatise on Brushes and Commutation", *free of any charge.*

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Let us furnish you with specific information on our equipment to meet your requirements.

Quality EQUIPMENT for *Quality* PERFORMANCE

BENJAMIN LASSMAN & SON Route 8, GLENSHAW, PA.

New tapered bore TIMKEN® bearing has interference fit—yet can be removed easily

THIS Timken® TQIT bearing gives you maximum capacity for high-speed roll necks. It has an interference fit, yet it can be removed quickly and easily. All you have to do is expand its cones hydraulically.

This Timken roller bearing, like other Timken roll neck bearings, gives you better steel, more uniform gage and less scrap loss. That's because there's no need to change the screw-down pressure when the mill comes to speed.

To get into production, you make the screw setting, put the load on the Timken 4-row tapered roller bearings and start the mill rolling. Adjustment is maintained while mill operates under various loads and speeds.

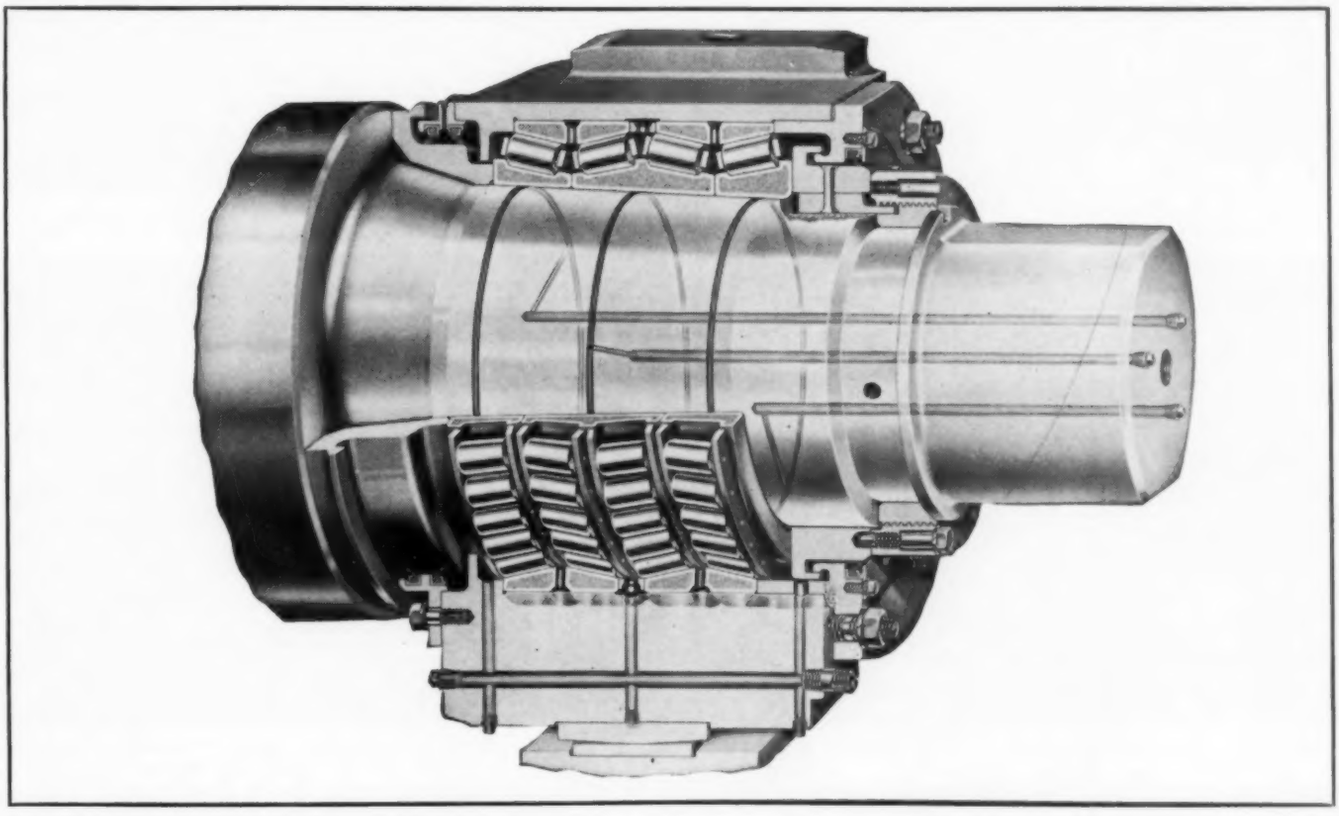
Timken bearings use economical grease lubrication. Complicated lubricating systems are eliminated. There's no loss of lubricant during roll changes. Rolls can be changed faster because there are no pipes or tubes. And there's less leakage of lubricant because Timken bearings keep housings and shafts concentric, making closures more effective.

There's no need for special thrust bearings because the tapered construction of Timken bearings enables them to take any combination of radial and thrust loads. And Timken bearings make possible higher mill speeds. Their true rolling motion and incredibly smooth surface finish practically eliminate friction. Starting resistance is reduced to a minimum. Result, no roll scuffing, no scoring of steel.

This is the world's first 4-row tapered bore bearing. And it's the greatest development in roll neck bearing design since the Timken Company pioneered the first balanced proportion bearing in 1941.

Write now for more information on how this new bearing can benefit your mill. Address The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



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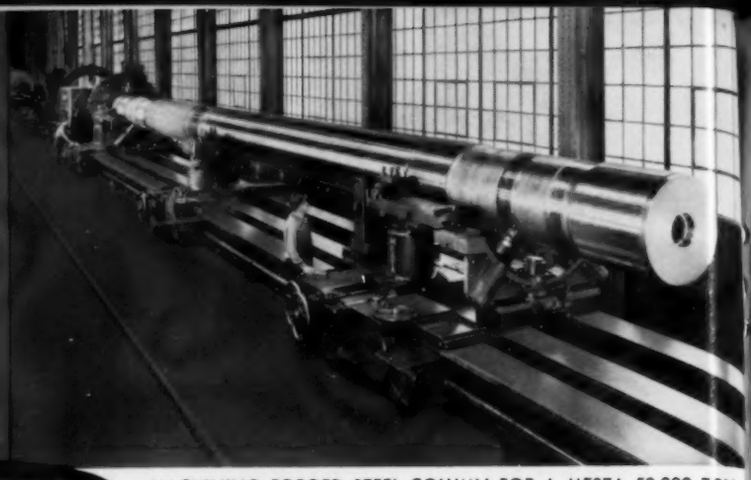
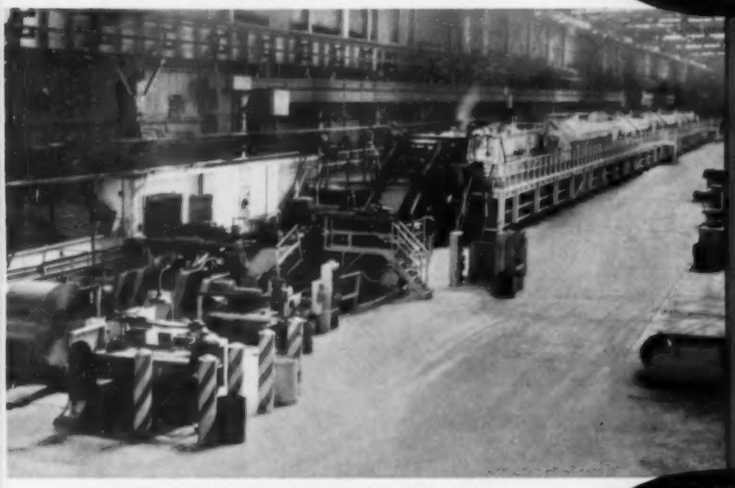
MESTA 60" SHEET SHEARING LINE WITH TRIMMER AND COMBINATION FLYING SHEAR AND LEVELLER

MESTA

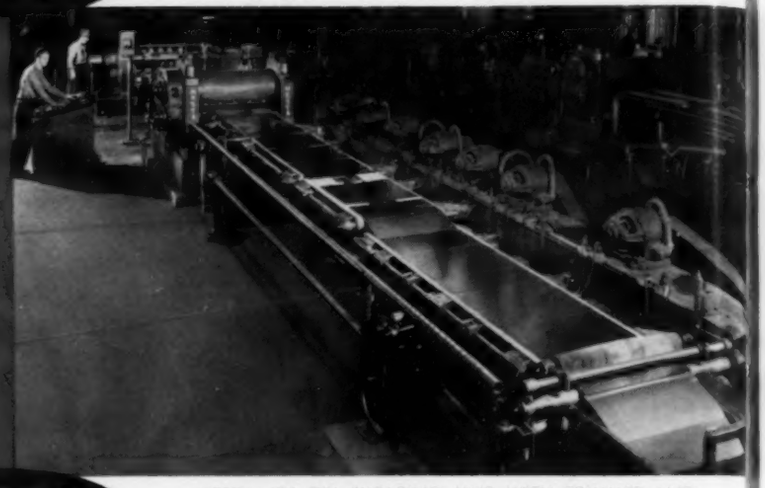


MACHINING FORGED STEEL COLUMN FOR A MESTA 50,000 TON HYDRAULIC PRESS ON A MESTA 96" HEAVY DUTY LATHE

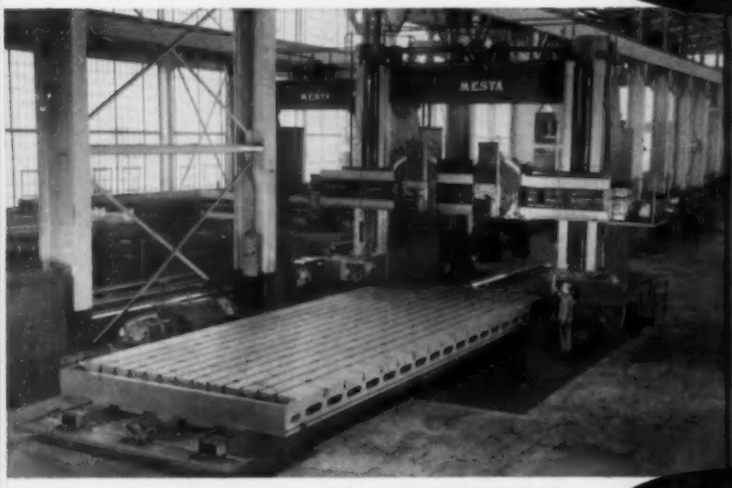


MESTA 60" CONTINUOUS PICKLING LINE WITH TRIMMER AND UP-COILER

MESTA



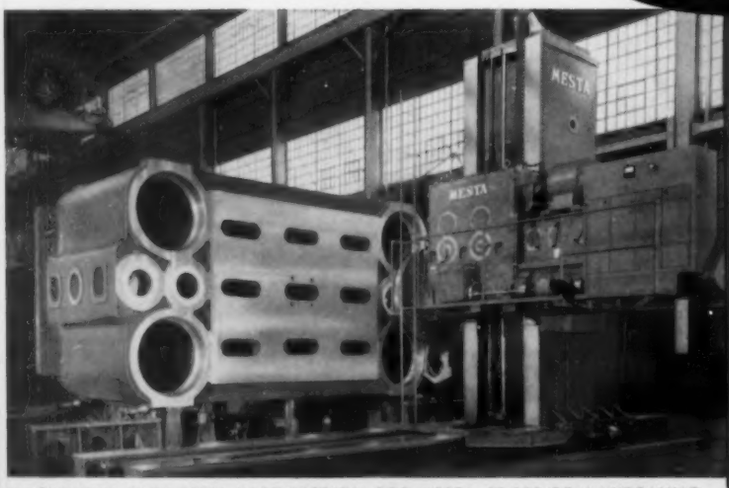
MESTA 42" TIN SHEARING LINE WITH TRIMMER AND COMBINATION FLYING SHEAR AND LEVELLER



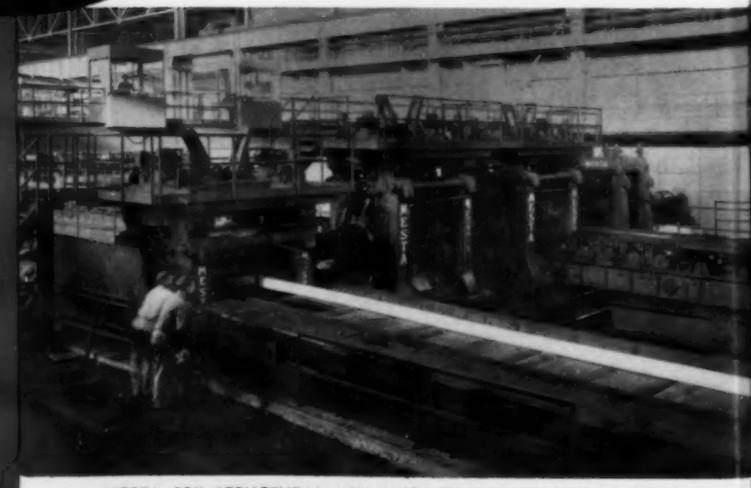
MESTA 15' HEAVY DUTY TRAVELING TABLE TYPE PLANER

MESTA

MESTA 46" TWO-HIGH REVERSING SLABBING-BLOOMING MILL WITH MANIPULATORS AND TABLES

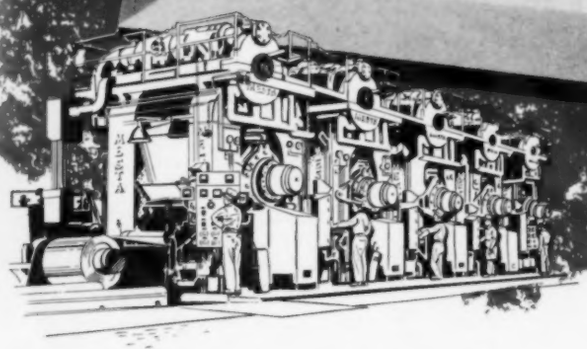


MACHINING CAST STEEL BASE SECTION FOR MESTA 50,000 TON HYDRAULIC



MESTA 29" STRUCTURAL MILL WITH TRAVELING TILTING TABLE

Designed and Built by MESTA



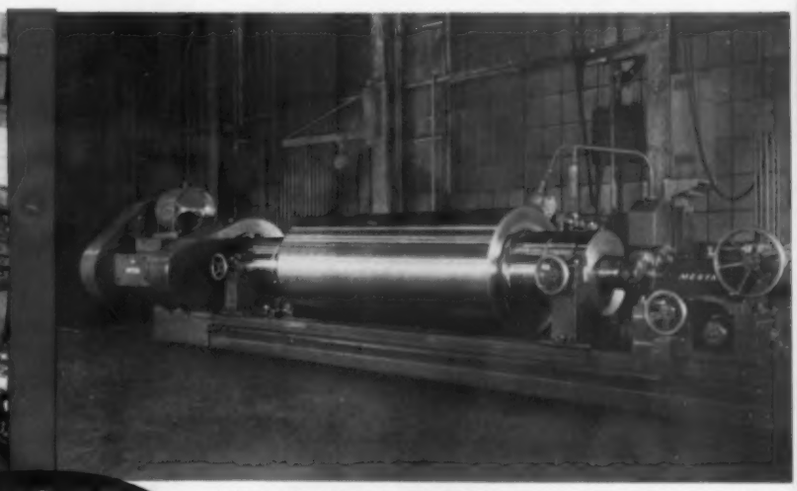
Engineers and Builders of Complete Steel Mills

MESTA MACHINE COMPANY

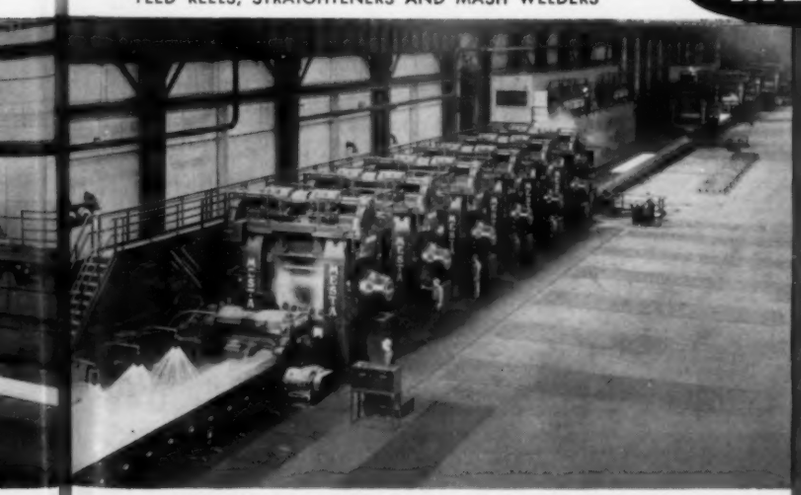
PITTSBURGH, PENNSYLVANIA

TWO MESTA 48" CONTINUOUS GALVANIZING LINES WITH FEED REELS, STRAIGHTENERS AND MASH WELDERS

MESTA



MESTA HEAVY DUTY TRAVELING WHEEL TYPE ROLL GRINDER FINISHING A LARGE MESTA BACKING-UP ROLL

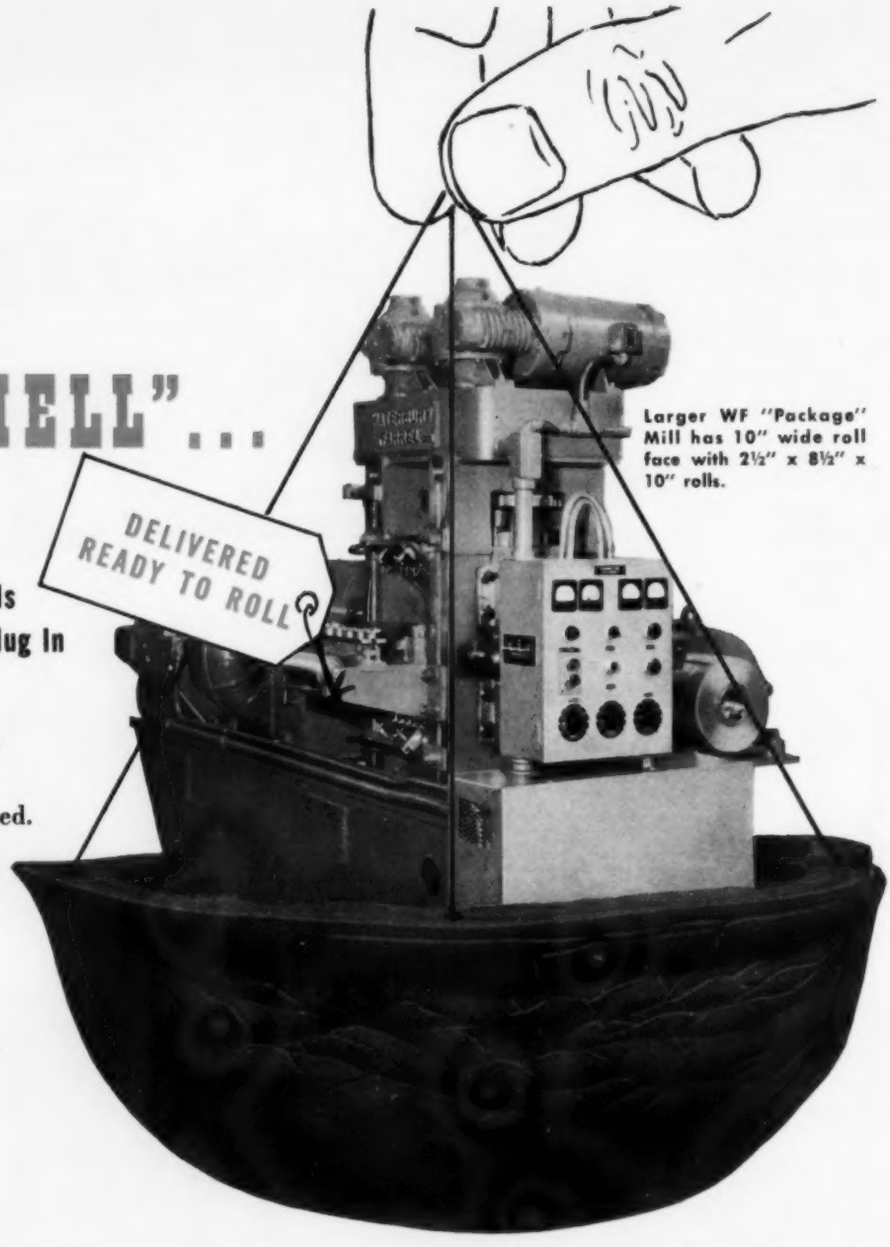


MESTA 80" FOUR-HIGH CONTINUOUS HOT STRIP MILL

MESTA 160" FOUR-HIGH REVERSING PLATE MILL

Waterbury Farrel's New, ONE-PIECE

STRIP MILL "IN-A-NUTSHELL"...

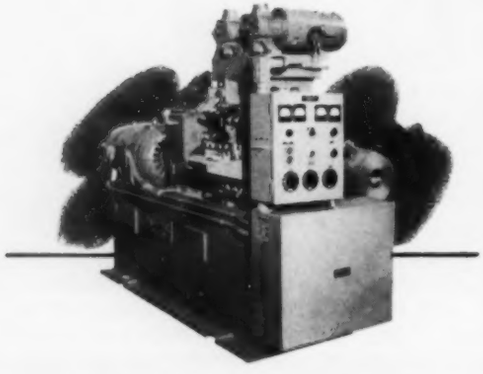


Larger WF "Package" Mill has 10" wide roll face with 2½" x 8½" x 10" rolls.

WF's 4-High "Package" Rolling Mills Are Compact, Low Cost, Ready To Plug In

You can start precision-rolling ferrous or non-ferrous strip as soon as you plug in the electrical connection.

This mill is completely self-contained. Drive, gear case, controls, lubrication system, winder and winder drive are assembled with the mill, itself, into a single, compact unit. When necessary, it can easily be moved in one piece to a new location.



Smaller WF "Package" Mill has 6" wide roll face with 1⅝" x 6½" x 6" rolls.

Some Construction Features: Mill frame of unit welded plate steel gives maximum strength and rigidity . . . assures greater accuracy and lasting alignment . . . alloy steel work rolls mounted in needle bearings . . . alloy steel back-up rolls drilled for water cooling, mounted in double row Timken bearings with tapered sleeve . . . independent power screwdowns . . . long and short roll necks and staggered couplings permit heavier construction for maximum torque capacities . . . lucite cover on welded steel gear case facilitates inspection . . . variable speed tension control drive, using AC power, cuts control cost and permits compact panel.

Contact Waterbury Farrel for complete details. No obligation.

WATERBURY FARREL FOUNDRY & MACHINE CO. • WATERBURY, CONN.

Offices: Chicago, Cleveland and Millburn, N. J.

A FEW OF THE MANY TYPES OF METAL WORKING MACHINERY MADE BY WATERBURY FARREL

MILL MACHINERY—Rolling Mills: Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc. *WIRE MILL EQUIPMENT*—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCESS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

WATERBURY FOUNDED 1851 FARREL

WF-17

Hands Off!

EC&M TAB-WELD RESISTORS REQUIRE MINIMUM MAINTENANCE

Only EC&M TAB-WELD Plate Resistors are both bolted and welded for constant current path. Unlike other resistors, they do not require periodic tightening of clamping nuts to compensate for loss of pressure caused by alternate heating and cooling. In TAB-WELD Resistors, grids are offset and mating ends spot welded. Tap-plates are also welded into place at close intervals along the grid assembly.

This exclusive EC&M construction offers these outstanding advantages: (1) stabilized ohmic value, (2) no burning at grid-eyes or at tap-plates, (3) easy tap-shifting for best motor performance, and (4) long life with negligible service.

So . . . hands off EC&M TAB-WELD Plate Resistors . . . they are constructed for dependable performance on heavy duty motor applications . . . with minimum maintenance!

1794

CHECK THESE ADVANTAGES!

- Nonbreakable
- Corrosion-resistant alloy steel
- Negligible resistance change between cold and maximum working temperatures
- Offset resistor ends spot-welded
- No burning at grid eyes
- No burning at taps
- Small adjustments in resistance value easily made
- Insulating spacers remain dimensionally stable
- No periodic tightening of clamping nuts
- All standard sections same size
- Double insulation to ground
- Fast connection to any tap plate

Write today for illustrated Bulletin No. 942-B for complete data on EC&M TAB-WELD Resistors.

THE ELECTRIC CONTROLLER & MFG. CO.

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ELECTRICAL CONSTRUCTION IN STEEL MILLS FOR 36 YEARS

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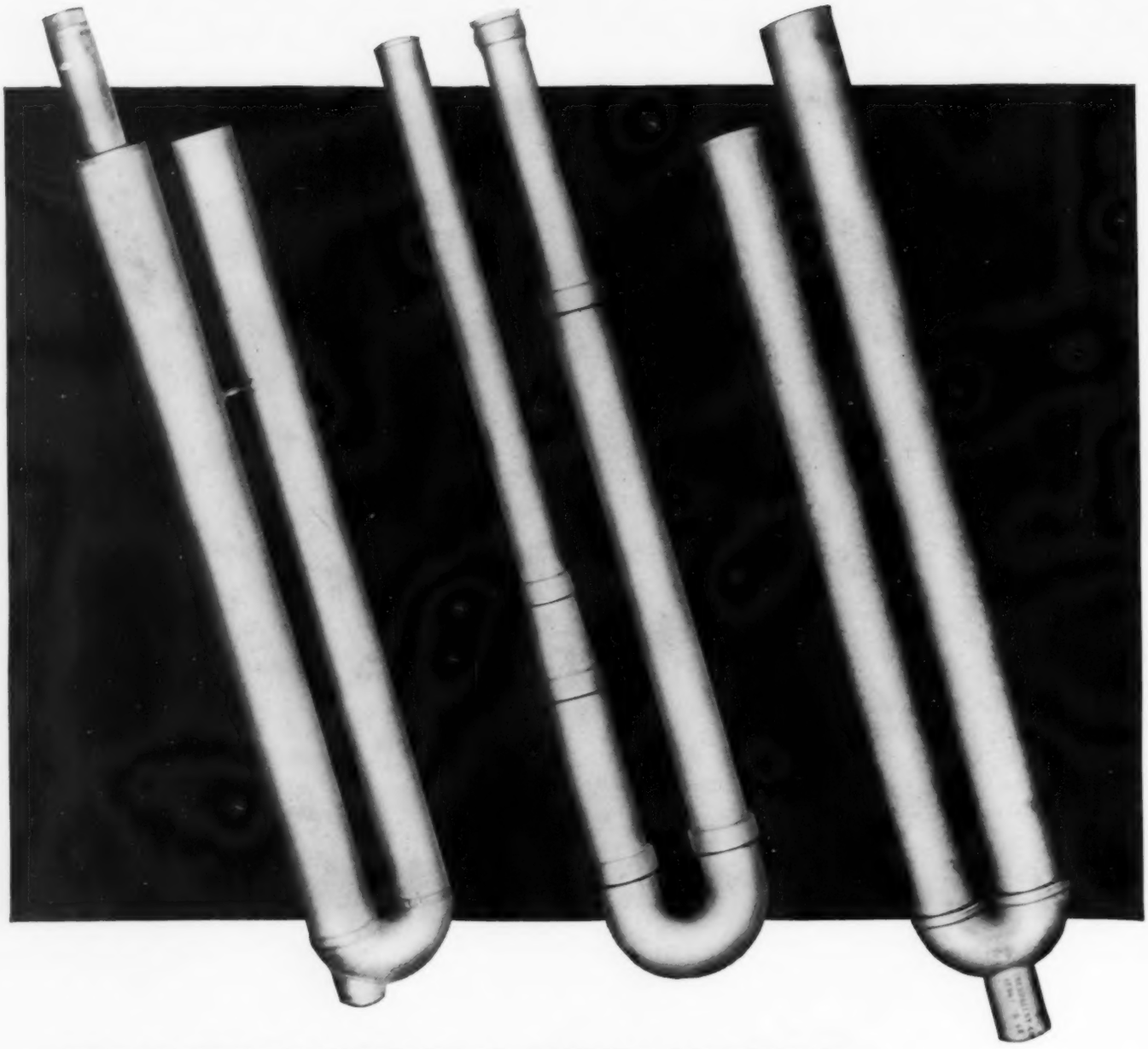
Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other Heavy Machinery. Manufacturers of Iron, Nodular Iron and Steel Castings, and Weldments.



GET MORE HOURS OF SERVICE FROM

Thermalloy* radiant tubes

Make Electro-Alloys your source if you want radiant tube assemblies that will give more life and reduce maintenance costs.

All components are produced in suitable analyses under close metallurgical supervision, and with X-ray control. The straight tube sections are centrifugally cast in such a way that wall thickness is uniform throughout; i. e., inside diameter and outside diameter are concentric, and thickness is the same the full length of the tube. All finished assemblies are pressure-tested before shipment to insure freedom from leakage. As a result, you are assured of radiant tube assemblies that last longer without cracking, warping or sagging.

Whatever your needs in radiant tube assemblies or other heat-treating equipment—you'll get more operating economy from high heat-resistant Thermalloy castings. Let us know your requirements. Call your nearest Electro-Alloys engineer or write Electro-Alloys Division, 5006 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

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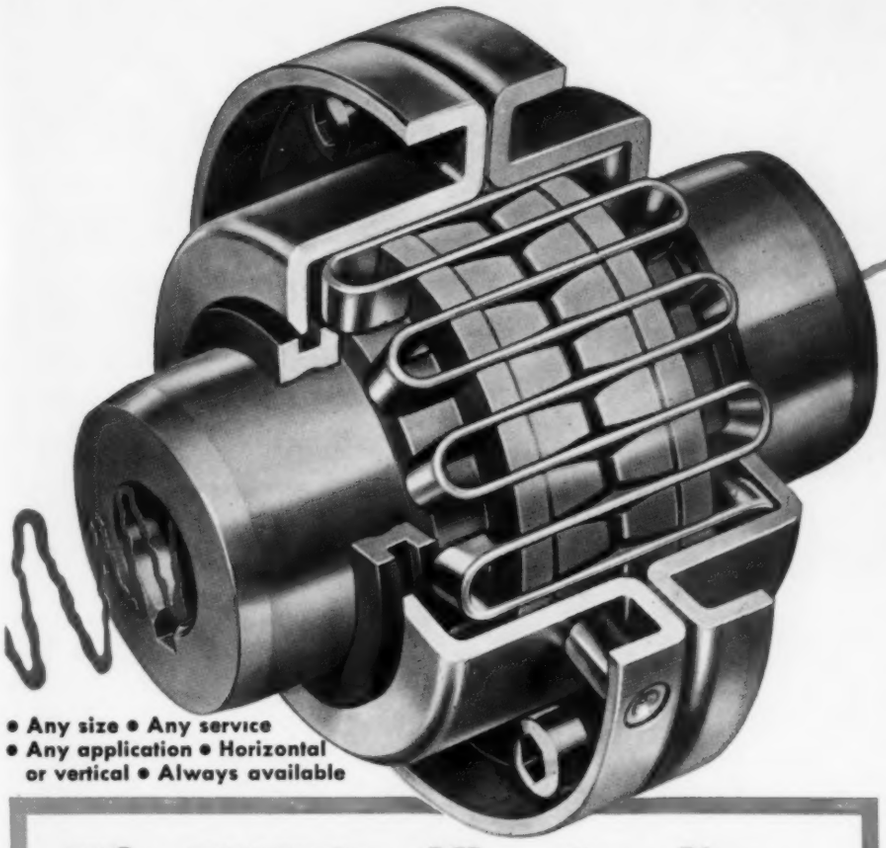
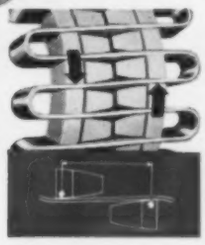


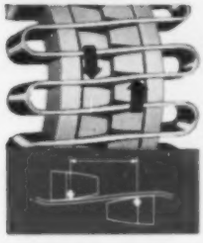
• Any size • Any service
• Any application • Horizontal or vertical • Always available

Exclusive FALK Steelflex grid-groove design smothers shock and vibration.

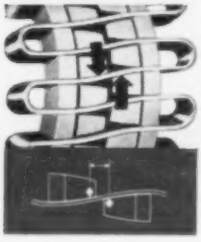
The damaging effects of shock and vibration can shorten the life of any connected machinery. Here is how the Steelflex grid-groove design overcomes these common enemies.



Under LIGHT LOADS
The gridmember bears only at outer edges of grooves. The long span between points of contact remains free to flex under load variations.



Under NORMAL LOADS
As load increases, the distance between supports on the grooves is shortened proportionately, but a free span remains to cushion shock loads.



Under SHOCK LOADS
Under extreme overloads, the grid-member bears fully on the grooves and transmits full load directly. The coupling remains flexible, within its rated capacity.

Why FALK Steelflex Couplings give the *finest* protection for connected machinery

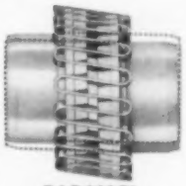
Maximum protection of connected machinery is best provided by Falk Steelflex Couplings because, thanks to their exclusive design, they overcome the damaging conditions of shock loads, shaft misalignment and vibration. How this unique multiple protection is made possible is shown at the right.

Falk Steelflex Couplings give the most economical protection, too, because they make connected machinery last longer and give better service. Furthermore, when actual coupling costs are figured per year of service, Falk Steelflex Couplings show substantial savings through their rugged all-steel construction, easy interchangeability and low maintenance requirements.

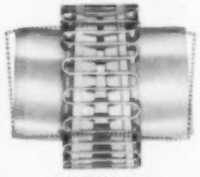
The basic Type F Steelflex Coupling—in 33 sizes to cover capacities from 2/5 through 70,000 hp per 100 rpm—meets over 90% of all industrial applications. Special or Dual Purpose Steelflex Couplings are available for problem applications. Write to Department 247 for engineering bulletin, including selection and dimension details.

...Accommodates shaft misalignment and free end float

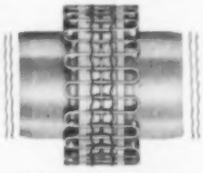
Basic maintenance procedure dictates regular inspection and correction of shaft alignment. Between inspections, Steelflex couplings provide protection by accommodating unavoidable shaft misalignment and end float. The gridmember which connects the two hubs of a Steelflex coupling is not fastened to either hub, so each hub can shift without imposing load on the other shaft.



PARALLEL MISALIGNMENT



ANGULAR MISALIGNMENT



FREE END FLOAT

THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

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- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
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FALK

...a good name in industry

another new—service-proved—
HARBISON-WALKER PRODUCT
semi-silica fireclay refractory of super-quality

For Soaking Pits	For Blast Furnace Stoves	For Open Hearth Regenerators	For Hot Metal Mixers	For Heating Furnaces

service

KAOSIL, having an added margin of the particular, beneficial properties of semi-silica fireclay brick is a truly unique refractory. The enhanced physical and chemical properties of KAOSIL extend the range of usefulness of the highly siliceous type of fireclay refractories.

composition

KAOSIL is made from exceedingly fine grained siliceous kaolin of exceptional purity and uniformity. Its silica content is approximately 75 percent and its content of basic oxides of alkalies and alkaline earths is phenomenally low—less than 1 percent.

superior characteristics

KAOSIL has exceptional stability under load in soaking heats of long duration.

Purity in composition of KAOSIL accounts for its high refractoriness and high temperature of vitrification.

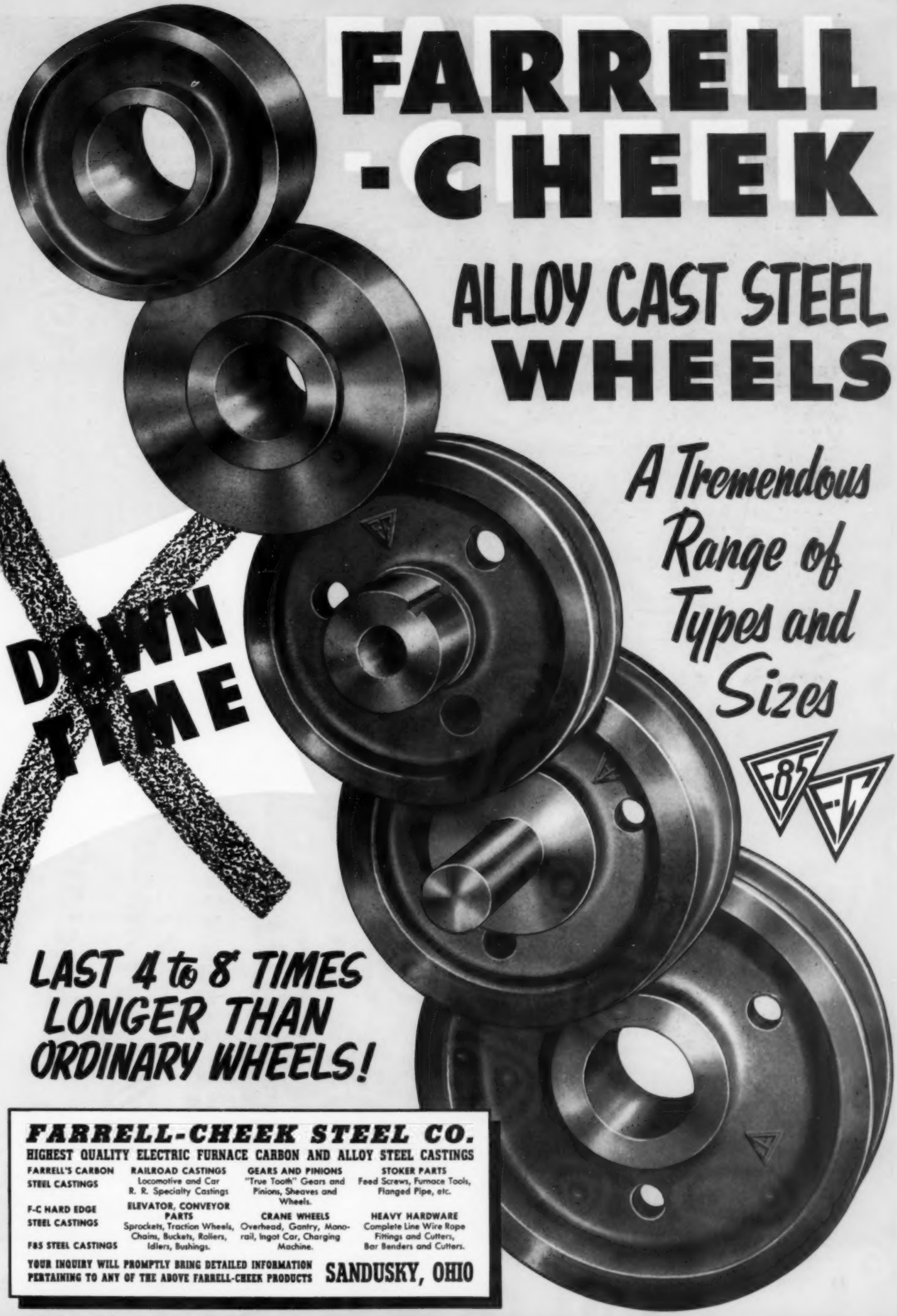
The resistance of KAOSIL to structural spalling and fluxing by alkali laden gases are other properties of prime importance.

Excellent workmanship is assured by the power press method of forming.

HARBISON-WALKER REFRACTORIES CO.
AND SUBSIDIARIES
World's Largest Producer of Refractories
GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

FARRELL -CHEEK

ALLOY CAST STEEL WHEELS



A Tremendous Range of Types and Sizes

85 F-C

DOWN TIME

LAST 4 to 8 TIMES LONGER THAN ORDINARY WHEELS!

FARRELL-CHEEK STEEL CO.

HIGHEST QUALITY ELECTRIC FURNACE CARBON AND ALLOY STEEL CASTINGS

FARRELL'S CARBON STEEL CASTINGS

F-C HARD EDGE STEEL CASTINGS

F85 STEEL CASTINGS

RAILROAD CASTINGS
Locomotive and Car R. R. Specialty Castings

ELEVATOR, CONVEYOR PARTS
Sprockets, Traction Wheels, Chains, Buckets, Rollers, Idlers, Bushings.

GEARS AND PINIONS
"True Tooth" Gears and Pinions, Sheaves and Wheels.

CRANE WHEELS
Overhead, Gantry, Monorail, Ingot Car, Charging Machine.

STOKER PARTS
Feed Screws, Furnace Tools, Flanged Pipe, etc.

HEAVY HARDWARE
Complete Line Wire Rope Fittings and Cutters, Bar Benders and Cutters.

YOUR INQUIRY WILL PROMPTLY BRING DETAILED INFORMATION PERTAINING TO ANY OF THE ABOVE FARRELL-CHEEK PRODUCTS

SANDUSKY, OHIO

VICTOR R. BROWNING

Mill Type Cranes

TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

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DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

FOR BRONZE PARTS

a choice of 5 casting methods to increase design flexibility . . . and lower metal and machining costs

There's one best way to cast a part. National Bearing is *equipped* to use the method that will provide a sound casting and allow you greatest savings in metal weight and a minimum of machining.

If desired, NBD will do all required machining—rough or finished—and deliver parts ready to use.

Delivery is fast because there are six strategically located National Bearing plants. Reduced transportation costs provide added savings.

Begin now to profit by NBD's 80 years of casting experience. Send us your prints. Our bids are based on the most suitable casting method. Orders will be filled promptly.

Write for the new folder *Copper and Bronze Castings and Bearings for Blast Furnaces.*

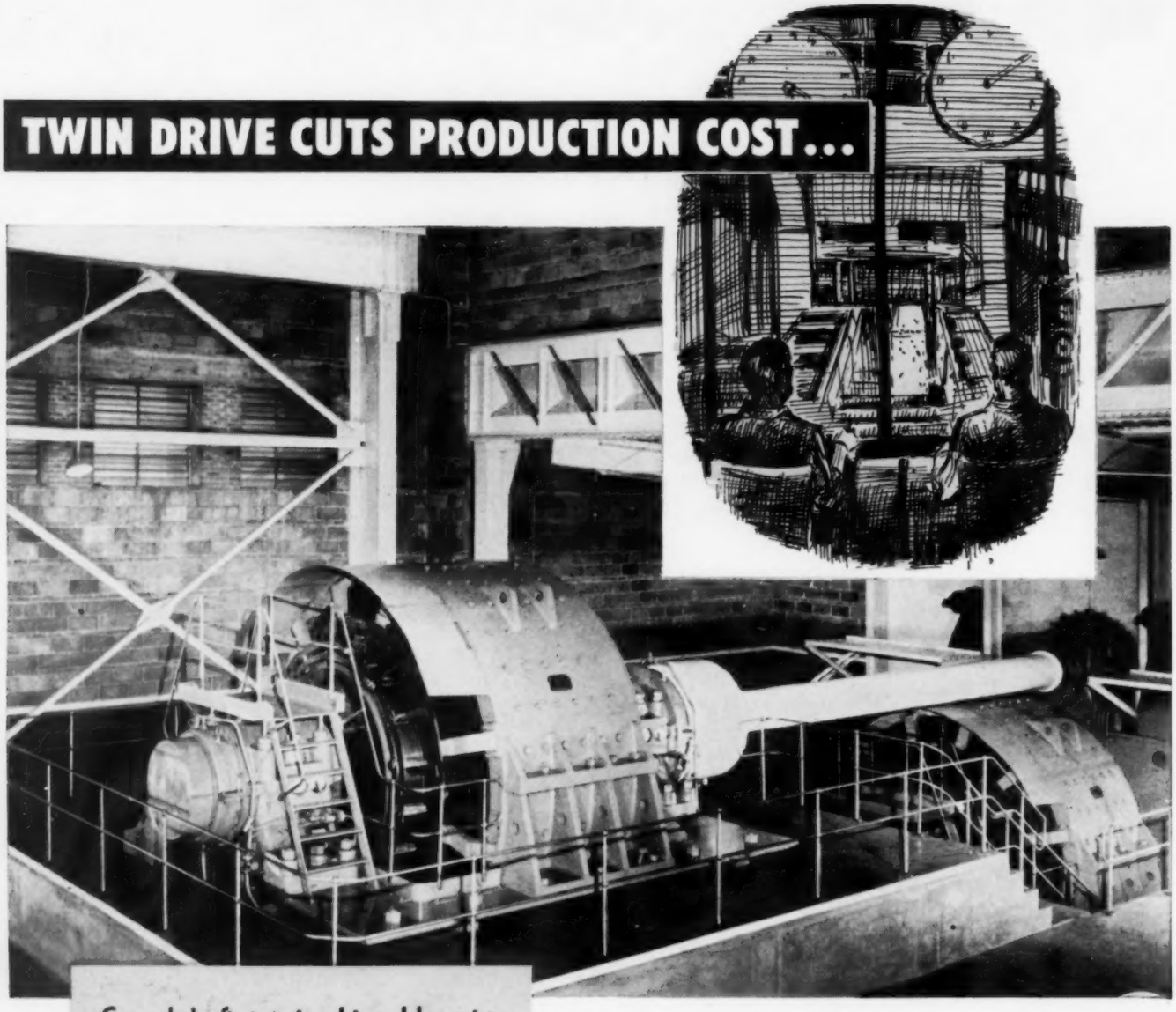
AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4930 Manchester Avenue, St. Louis 10, Mo.

Plants in: **St. Louis, Mo. Meadville, Pa. Niles, Ohio Portsmouth, Va. St. Paul Minn. Chicago, Ill.**

TWIN DRIVE CUTS PRODUCTION COST...



Canada's first twin drive blooming mill is cutting production costs for Dominion Iron & Steel Limited, a subsidiary of DOSCO.

The twin drive, where each work roll has its own motor —

- eliminates pinion housing and saves an energy loss of approximately 4 to 5%
- cuts out pinion lubrication and maintenance costs
- cuts reversing peak current by reduced motor inertia
- reduces roll wear by cutting out slip due to different roll diameters
- provides increased rolling efficiency

Each motor in this installation at Dosco's Sydney plant develops a peak of 10,500 H.P.; together give a total of 21,000 H.P.

PA5409

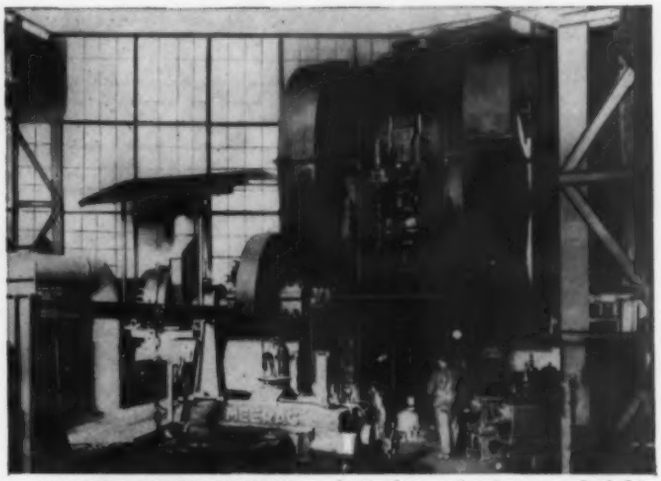
For thirty years, English Electric have built drives for hot and cold rolling mills of every kind and the value of this experience is yours for the asking. If you have a mill drive problem, whether it be power supply, substation, cabling, ventilating or complete layouts, give us a call. Our publication MT/108 describing the rolling mill twin drive is available on request.

ENGLISH ELECTRIC

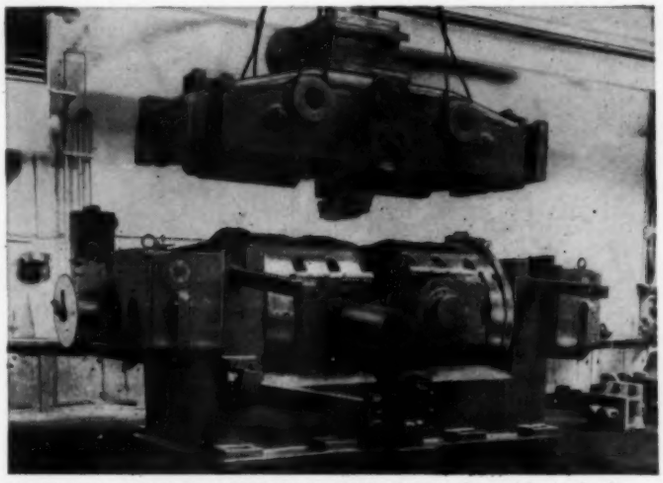
Vancouver, Calgary, Winnipeg, Toronto, Ottawa, Montreal and Halifax.
English Electric Company of Canada Limited, St. Catharines, Ontario.

New mill machinery speeds seamless tube production

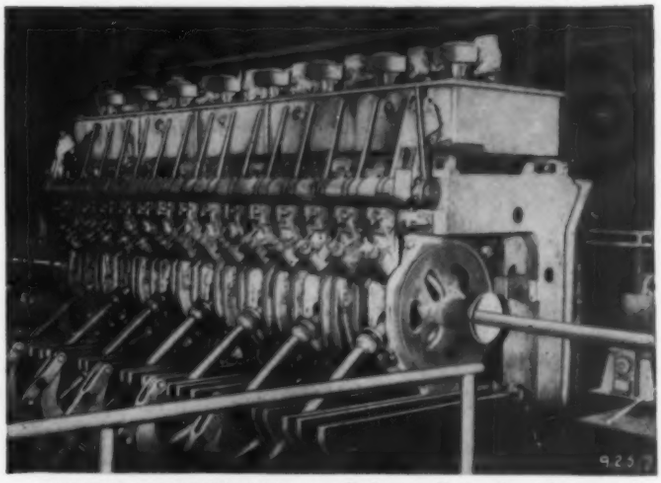
HIGH OPERATING SPEED of Mannesmann-Meer automatic return mill boosts production, cuts costs in any automatic mill plant. Special guides in mandrel bed aid quick changeover of schedules.



180 STEEL TUBES PER HOUR — that's the production record of this mechanical extrusion press. We also offer high-speed hydraulic extrusion presses for the non-ferrous industries.



HEAVY-DUTY REELER WITH ROLL OBLIQUITY adjustable in both planes, has individual motor drive for each roll. Permits use of a plug of any taper for any desired expanding action. All Mannesmann-Meer reelers are extra heavy and rugged in construction with anti-friction bearings throughout to assure best possible rolling conditions.



INCREASE OD REDUCTION at each three-roll stand on this stretch-reducing mill. New low-cost group drive permits speed adjustment for each stand. Special stand changing device provides for quick schedule change. These same features are available for continuous mandrel mills. Many outstanding design features are also available for both sinking and sizing mills.

Got production bottlenecks on seamless tubes?

At Mannesmann-Meer you'll find complete mills or mill machinery designed and built specifically to speed production and cut costs.

We're the *only* manufacturer of tube mill machinery who can draw on over 65 years of experience in the *operation* as well as the design of complete seamless mills. Let us put this production and engineering know-how to work for you.

Examples of some of our new developments in mill machinery are shown here. Mechanical and hydraulic extrusion presses — piercing mills — automatic return (plug) mills — continuous mandrel mills — heavy-duty reelers — assel mills — pilger mills — expanding mills — sizing mills — stretch-reducing mills — large electric weld pipe mills — rotary straighteners — tube reducing machines — are but a few of the many products in our complete line.

MANNESMANN-MEER

ENGINEERING & CONSTRUCTION COMPANY

900 Line Street, Easton, Penna.

WORLD SPECIALISTS IN HIGH-SPEED TUBE-MILL MACHINERY

Quick Quenching
EXTENDS CONTACT LIFE!

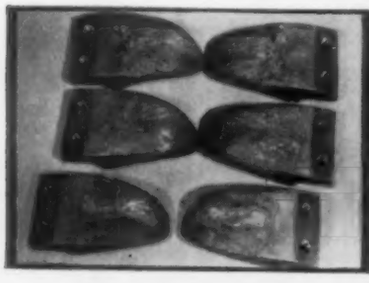
1 Arc, forced upward along runner by magnetic field of blowout coil, impinges upon metal segments of arc chute.
2 As contact separates, arc is stretched across increased number of segments. The arc rises quickly due to thermal convection and magnetic action.
3 Resistance in arc path increases as number of gaps increase. Metal elements help cool path while arc races to extinction.

Because arc is extinguished quickly, destructive burning and pitting of contacts is minimized.

CONTACT BURNING is the most troublesome and costly maintenance factor in an interrupting device subjected to repeated overloads. In the Allis-Chalmers Type 260 contactor a quick-quenching arc centering blowout solves the problem by sharply curtailing arcing time.

No Contact Erosion After Punishing Tests

Pictured below are contacts removed from a 600-amp experimental starter after extreme overload tests. In addition to great number of interruptions at rated current and below, these tests included 70 interruptions spread between 700 and 11,000 amperes and two interruptions above 13,000 amperes. All testing was done with the same set of contacts. A-4334



CONTACTS AFTER HIGH INTERRUPTION TESTS

ALLIS-CHALMERS Mill Type 260 DC CONTACTOR

For complete information on heavy duty dc contactors, call your nearby Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington, D. C., at 25 cents each . . . patents reviewed cover period from May 11, 1954 through June 8, 1954 . . . .

LOW-VOLUME HOT TOP

▲ THE conventional composite hot top consists of a cast iron casing lined with first quality fire brick blocks. Such blocks have a higher softening temperature than the temperature at which molten steels are poured, namely 2611 to 2950 F. They possess thermal shock resistance of an acceptable order to withstand first the considerable shock attendant upon filling the hot top when molten metal comes into intimate contact with the relatively cold brick lining, and second when the hot top, the face of whose brick lining may be at a temperature as high as 2400 F, is stripped off the sinkhead and cold air rushes up through it to wipe these hot surfaces. These bricks also possess good mechanical strength to withstand the abuse given a hot top upon stripping and handling. When a crane man pulls a hot top off a sinkhead, it is rare that a straight up axial lift is achieved, and the consequent cocking action must be resisted by the brick lining.

The heat losses for a hot top employing fire bricks of the first quality grade are considerable, due to their thermal conductivity and their high heat capacity. These losses result in the freezing of metal along the walls of the hot top to form the sinkhead. The volumetric capacity of the hot top therefore must provide sufficient metal for the sinkhead in addition to that supplied to insure adequate feeding of molten metal into the shrinkage cavity of the solidifying ingot. A conventional hot top must have an enclosed volume of approximately 15 per cent of the total. Only about 4 to 6 per cent is necessary to feed and insure ingot soundness. The balance of 9 to 11 per cent represents waste, loss or scrap and is an item which every steel plant is vitally interested in reducing.

In U.S. 2,678,481, issued May 18, 1954 to Gustave A. Peterson, assigned to The Ferro Engineering Co. a low-volume, high-efficiency hot top is described, which uses high insulating brick protected by a veneer of refractory mortar.

A porous fire brick of an intermediate grade having safe working temperatures in the range of 2200 to 2600 F, having a heat conductivity of about one-third or less of that first quality fire brick is used for insulation. A half inch or so of a moldable mortar is trowelled on the inner surface of the lining blocks. This prevents molten steel from contacting the insulating fire brick, and cuts down the transmitted heat enough to avoid overheating the surface of the insulating blocks. The veneer is soft enough to permit easy stripping of the hot top from the sinkhead, and it absorbs mechanical forces imposed by misaligned stripping.

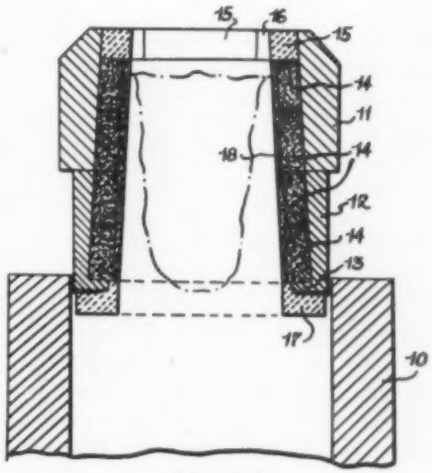


Figure 1

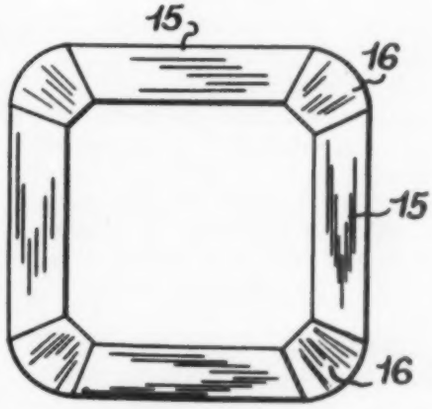


Figure 2

The hot top is shown in Figures 1 and 2. The casing of the hot top is

made up of two iron castings 11 and 12, for economy in manufacture and maintenance. At the lower end of the casing there is a ledge 13, and on this ledge are supported insulating blocks 14. These blocks are fire brick whose insulating qualities depend upon high porosity effected by burn-out material incorporated in the mix, which burns upon the firing of the brick. They are light in weight and fragile. They are made in various grades, those having the best insulating qualities being adapted for use in top service temperatures very much less than the pouring temperature of steel. Such brick will not withstand mechanical abuse nor the penetration of their porous structure by liquid metal or slag, in which respect they differ markedly from first quality fire brick.

The insulating blocks 14 are laid up in one or more courses depending somewhat upon the size of the hot top. They terminate at a level well below the top of the casing. The joints are filled with high temperature cement which also functions to attach them together as well as to prevent the flow of metal into the cracks between the bricks.

The upper course of the lining is made up of a hard fire brick blocks. In the illustrated case, the hot top being square, the blocks may be of two styles only, namely sidewall blocks 15 and corner blocks 16. They are also cemented to each other and to the uppermost course of insulating blocks 14. Blocks 15 and 16 are so dimensioned as to project inwardly beyond the blocks 14 a distance of about one half inch.

Below the lower end of the casing there is a refractory bottom ring 17 which is secured to the casing by conventional wire clips, not shown, which are adapted to fail when contacted by the molten metal, and thus to permit the bottom ring to remain on the ingot when the hot top is stripped therefrom. This bottom ring protects the lower and inner sides of the ledge 13.

Before each heat is poured, a veneer coating 18 is applied to the inner surface of the insulation blocks 14.

When the veneer has been applied it must be dried before the hot top can be used. Drying can be accomplished preferably by subjecting the veneer or the entire assembly to the action of hot air.

BLAST FURNACE TUYERE

A blast furnace tuyere is described by John H. Sprow in U.S. 2,679,390, issued May 25, 1954. The tuyere is shown in Figures 3, 4, and 5, the last figure being a sectional view at the inlet end. The tuyere 5 is provided with a water jacket 6. An axial bore 7 is provided for receiving the air blast and directing it into the furnace.

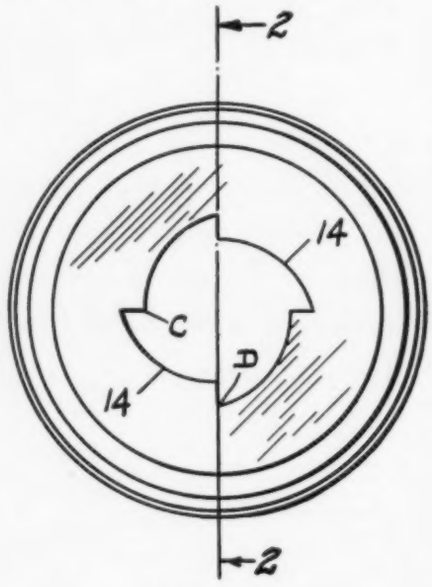


Figure 3

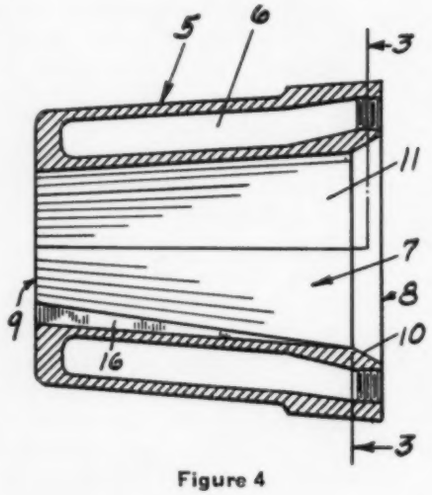


Figure 4

The inner wall of the tuyere is divided into blast-directing segments 11 which extend the full length of the tuyere and which are disposed side-by-side around the complete circumference of the bore. These segments are arranged in pairs, each pair consisting of two diammetrically opposed segments. Each segment 11 has a taper from the inlet end of the bore to the outlet end of the bore. The curvature of each segment 11 at the inlet end of the bore 7 is concentric with the curvature of the other segments so that the segments 11 merge with each other at the inlet end, as illustrated in Figure 5 along a circle 12 which is at the inner surface of the bore 7 and which has its center at the axis 13 of the bore. However, on the other end, the segments are not concentric, and their respective centers are not located on the bore axis 13.

The relative arrangement of the curvature 14 of the various segments 11, at the nose end of the tuyere, results in the formation of a radial shoulder 16 between each pair of adjacent segments 11. This shoulder 16, as shown in Figure 4 is of maximum inward height at the nose end of the bore 7 and gradually diminishes in extent until the inlet end of the bore is reached where it disappears.

When the blast of air is forced into the inlet end of the bore 7, the segments 11 will gradually twist the stream about the axis of the bore so that when it is discharged from the outlet end, the outer border will have a whirling motion. This whirling mo-

Figure 5

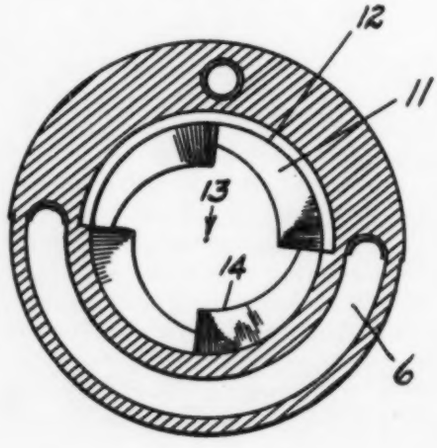
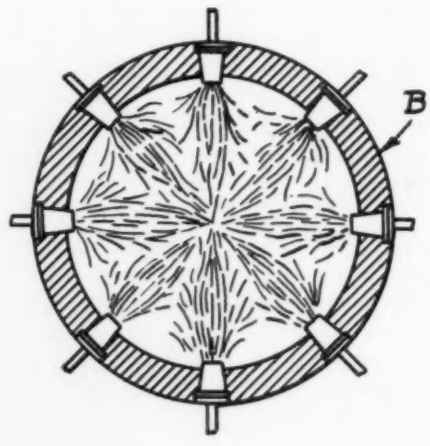


Figure 6



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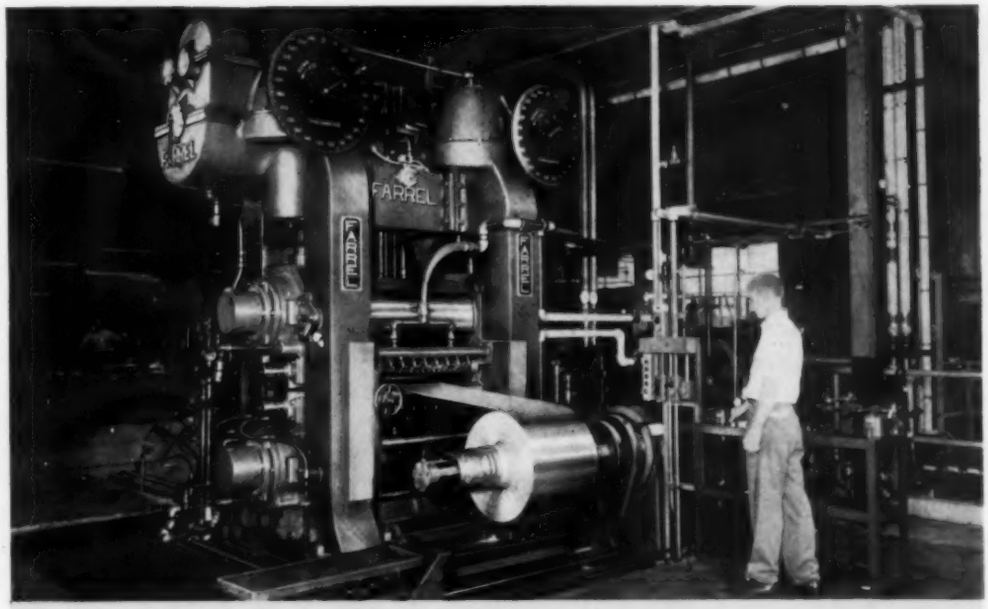

4-High Aluminum Foil Mill

Designed specifically for increasing aluminum foil production, this mill has 9" x 46" work rolls and 21" backup rolls. The speed of mill operation can be varied to meet production requirements by means of an adjustable-voltage control system.

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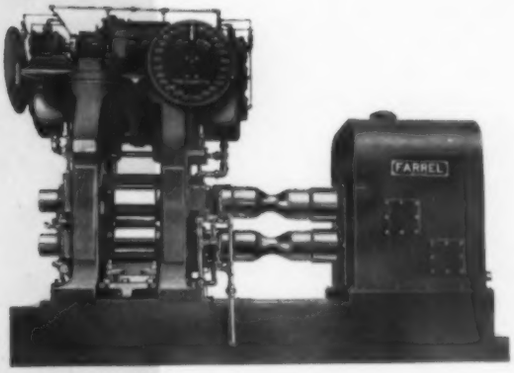
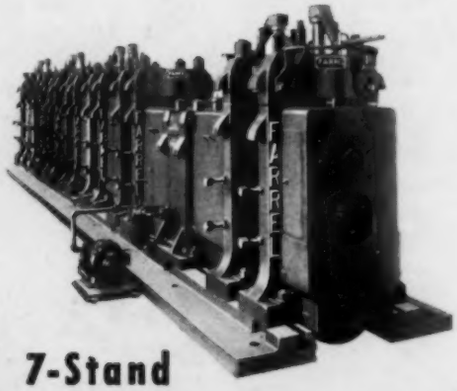
10" x 10" mill specially designed for close gauge control in continuous high-speed, cold rolling of high-carbon strip steel.





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tion will give a deeper penetration towards the vertical axis of the blast furnace as shown in Figure 6. Because of the gradual taper in both the longitudinal and transverse directions, the bore will accept the blast with very little resistance. The air will not only penetrate towards the axis of the furnace, because of the whirling or twisting action, but will spread outwardly, because of the diverging surfaces of the opposed segments 11. The transverse taper of the segments can be made left or right so that the whirling or twisting action of the blast can be made clockwise or counterclockwise. Although a twisting action is produced on the stream, this is accomplished without the use of helical ribs which would make cleaning more difficult.

INTRODUCTION OF MAGNESIUM INTO MOLTEN IRON

Magnesium is added to cast iron to produce nodular iron and to desulphurize and deoxidize the iron. Although magnesium need be introduced in only small amounts to the cast iron, the introduction of the magnesium brings about many problems. For example, magnesium boils at about 2030 F, and thus is gaseous at molten iron temperatures. Furthermore, magnesium burns explosively in air so that there is considerable danger connected with its use. Because of the great advantage of magnesium in preparing cast iron, however, many attempts have been made to develop safe and accurate methods and apparatus for introducing a predetermined amount of magnesium to iron.

Among the methods proposed in the past for solving the problems involved in adding magnesium to iron has been to use magnesium alloys of which nickel-magnesium and copper-magnesium have been found to be most suitable. Although magnesium can be introduced in this manner, this method has not been too successful as the amount of magnesium must be kept rather small. For example, the magnesium in each of these two alloys should not be more than about 20 per cent. Thus the amount of nickel or copper in the iron can build up to undesirable proportions where iron containing scrap is inoculated repeatedly with the alloys.

In U.S. 2,678,266, issued May 11, 1954 to Lothar R. Zifferer, a device is provided which consists of a hollow nozzle immersed in the molten iron and means for vaporizing the magnesium before its introduction into the molten iron. The magnesium vapors are introduced under pressure beneath the surface of the molten mass. An inert gas such as helium is used in the preliminary flushing of the system, in order to remove air.

The apparatus requires no moving parts, and is compact and safe. It permits a higher rate of feed of the magnesium with very little cooling of the molten iron as the magnesium is preheated to a vaporizing temperature. Furthermore, by heating the passages for the melted metal, the dangers of clogging of the system and subsequent feed stoppage are practically eliminated.

CONTAINER FOR CONVEYING A BILLET THROUGH A HEAT-TREATING SALT BATH

Attempts have been made to utilize highly alloyed steels in forming containers for conveying steel billets through a heat-treating salt bath. These containers have been fabricated from bars and rods, usually welded, into container form. However, stress concentrations at sections of reduced cross-sectional area and sharp corners and at the welded joints, combined with the corrosive attack of the salt bath have resulted in failures of the containers after very short periods of service. The time to failure is accelerated by the high operating temperatures encountered in heat-treating the billets in the salt bath. Further, while the container must be sufficiently strong to support the weight of the billet to be treated, it must also provide ready access to the billet for the salt bath to effectively heat-treat the billet, and at the same time, provide adequate drainage of the molten salt bath when the container holding the billet is removed from the bath.

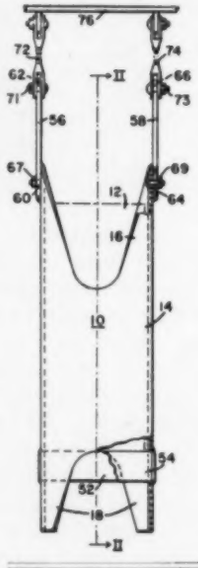

Figure 7

In U. S. 2,678,208, issued May 11, 1954 to Lloyd B. Sheetz and assigned to Allegheny Ludlum Steel Corp., a container is described which solves these problems.

As shown in Figures 7 and 8 a container 10 is used for conveying a billet 12 through a salt bath for heat-treating the billet. The container 10 consists of a cylindrical side wall 14 having open upper and lower ends 16 and 18. The side wall member 14 is formed from a carbon steel pipe, the upper end 16 being shaped in a sinuous manner to provide a pair of opposing upwardly extending appendages 20 and 22. The reverse curved notch portions 24 and 26 extend downward a sufficient distance along the side wall member so that the ends of each of the notches 24 and 26 are below the upper end portion of the billet 12. It is essential that there be no sharp corners or sections of reduced cross-sectional area which contribute to stress concentrations and accelerate the time to failure. At the same time, there must be sufficient physical structure to support the weight of the billet while providing adequate access of the salt bath (not shown) to the billet.

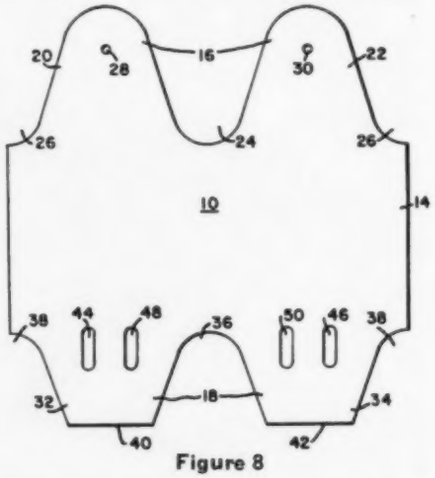

Figure 8

The lower end 18 of the cylindrical side wall member 14 is also shaped

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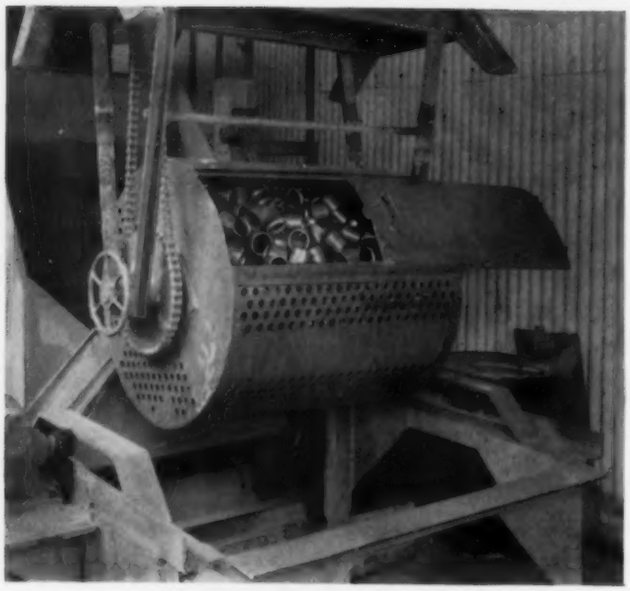

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in a sinuous manner. The notched portions 36 and 38 extend upwardly to expose the bottom edge of the billet 12 when positioned in the container 10. The lower extremities 40 and 42 are formed perpendicular to the longitudinal axis of the container 10 to provide feet for the container 10 whereby it may rest in an upright position when removed from the convenance mechanism.

In order to support the billet 12 in an upright position within the container 10, a number of bars 52 and 54 extend across the bottom portion 18 with the ends of the bars projecting through the slots 48-50 and 44-46, respectively, in the downwardly extending appendages 32 and 34. The bars 52 and 54 are composed of carbon steel and are of sufficient cross-sectional area to support the billet 12 when the container 10 is immersed in the salt bath operating at high temperatures. The ends of the bars which extend beyond the appendages 32 and 34 are secured in position to the side wall member by peening.

In order to suspend the container 10 within the salt bath, a pair of rigid straps 56 and 58 are secured to the upwardly extending appendages 20 and 22. The rigid straps 56 and 58 are preferably composed of stainless steel and are provided with openings 60-62 and 64-66, respectively, near the ends. The openings 60 and 64 in the rigid straps 56 and 58 are aligned with the openings 28 and 30 in the upwardly extending appendages 20 and 22. The straps 56 and 58 have the smallest cross-sectional area of the portion of the container 10 which is to be immersed, and are subject to the highest stress concentration so they are adapted for easy replacement.

The container 10 is also provided with a pair of non-rigid suspension means 72 and 74 of carbon steel connected to the rigid straps 56 and 58. Since they are not immersed in the salt bath nor are they subject to high operating temperatures, the problem of stress concentration is of no concern.

The container of this invention has the economic advantage of being formed from a carbon steel pipe as opposed to the usual containers of high alloyed steel and complicated structure. Further, since the container does not possess any sharp corners nor sections of reduced cross-sectional area which are points of stress concentration, the container has a life greatly in excess of any of the known containers at only a fraction of the cost. The notches in the upper and lower ends provide ready access of the salt bath to the billets for proper heat treatment while the container confines the billet in an upright manner during movement through the salt bath.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,677,978	5/11/54	Rolling mill	Frank P. Dahlstrom
2,677,979	5/11/54	End roll adjustment for a rolling mill	Birdsboro Steel Foundry & Machine Co.
2,678,289-90	5/11/54	Surface treatment for stainless steel	Freeport Sulphur Co.
2,679,389	5/25/54	Furnace structure	Inland Steel Co.
2,679,910	6/ 1/54	Portable derrick	United States Steel Corp.
2,679,914	6/ 1/54	Flue cleanout door	Inland Steel Products Co.
2,680,011	6/ 1/54	Annular heat-treating furnace	Holcroft & Co.
2,680,070	6/ 1/54	Stainless steel melting process	Armco Steel Corp.
2,680,466	6/ 8/54	Multiple rolling mechanism	James J. Ingels
2,680,493	6/ 8/54	Apparatus for removing fume from electric furnace gases	Mechanical Industries, Inc.
2,680,609	6/ 8/54	Tilting assembly for oscillating melting furnaces	Reda Pump Co.

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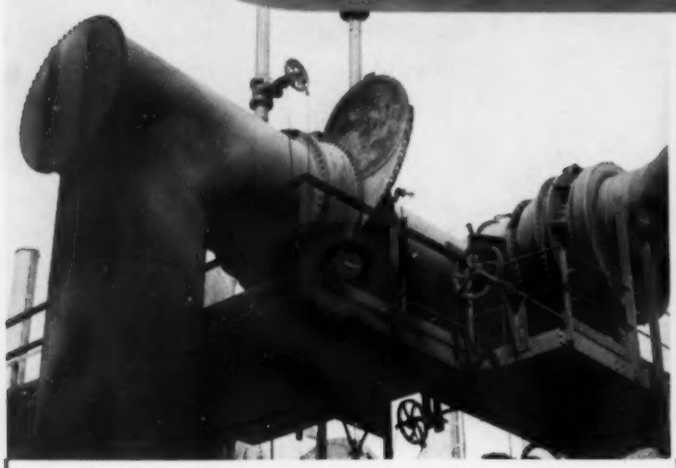

Mechanical Type

By means of a powerful clamping force applied equally at all points around the disc periphery, the Bailey Mechanical Goggle Valve provides a safe, tight seal for gas mains from 6" to 72" in diameter. The goggle plate is freed instantly by the same powerful mechanism, regardless of the length of time between operations. Both this type and Bailey Thermal Expansion Valves require only a minimum of maintenance.

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Designed for gas mains from 36" to 120", the Bailey Thermal Expansion type goggle valve operates by the linear expansion and contraction of three sets of steel tubes. When steam is applied, the tubes expand and separate the flanges, thereby freeing the goggle plate for swinging to open or closed position. When steam is removed, normal cooling contracts the tubes, which then clamp the flanges together to form a gas-tight leakproof seal. Can be hand-operated in case of steam failure.

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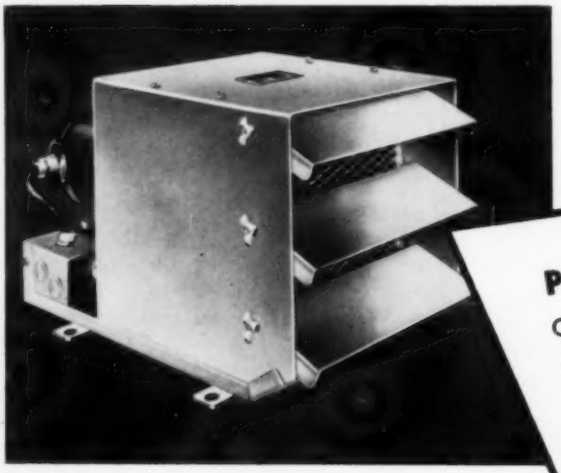

P-G Forced Convection Heater

Capable of moving a large volume of air with little noise. A 250 Volt D. C. Compound Wound Ball Bearing Motor of ¼ H. P. drives the fan. The heating circuit is controlled by a separately mounted 50-Ampere Magnetic Contactor energized thru a snap switch. The fan circuit is controlled thru a snap switch and contains a rheostat to vary the fan speed. Heating elements from 4 to 9 KW capacity, 230-250 Volts, D. C., are available.

P-G Natural Convection Heater

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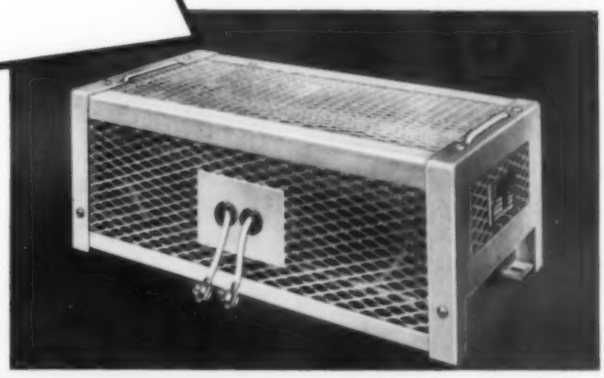
TWO TYPES of HEATERS are available for industrial service. The heating element of both units is made of P-G Type T2, Chromium Steel Grids, which, because of their thin cross section, develop an unusually large heating area. A greater volume of warm air is so produced, and in addition, a more uniform heat distribution is obtained.



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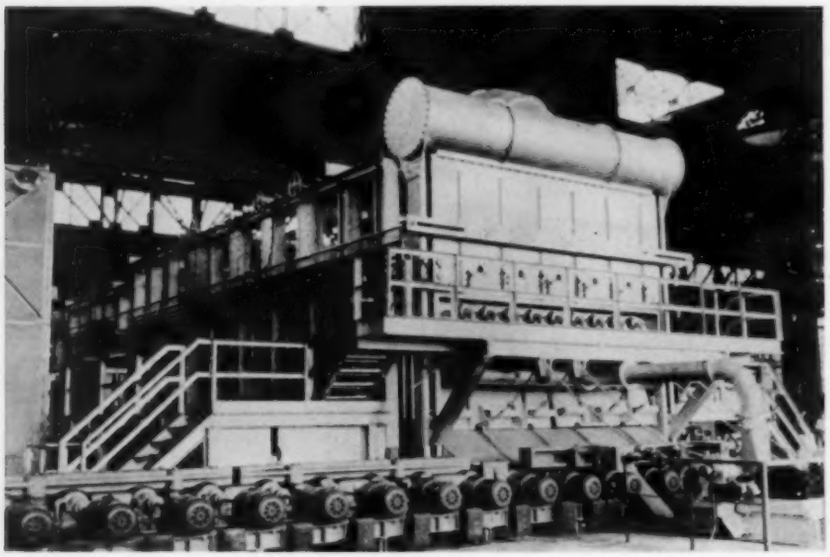
Fully automatic fuel, pressure and temperature controls assure correct fuel-air ratio at all times with minimum fuel consumption.

Throughout the world, Loftus engineers have designed and built all kinds of continuous furnaces including many types of multizone arrangements fired from above and below the work. You can depend on Loftus design and construction to give you the best quality heating at lowest possible cost.

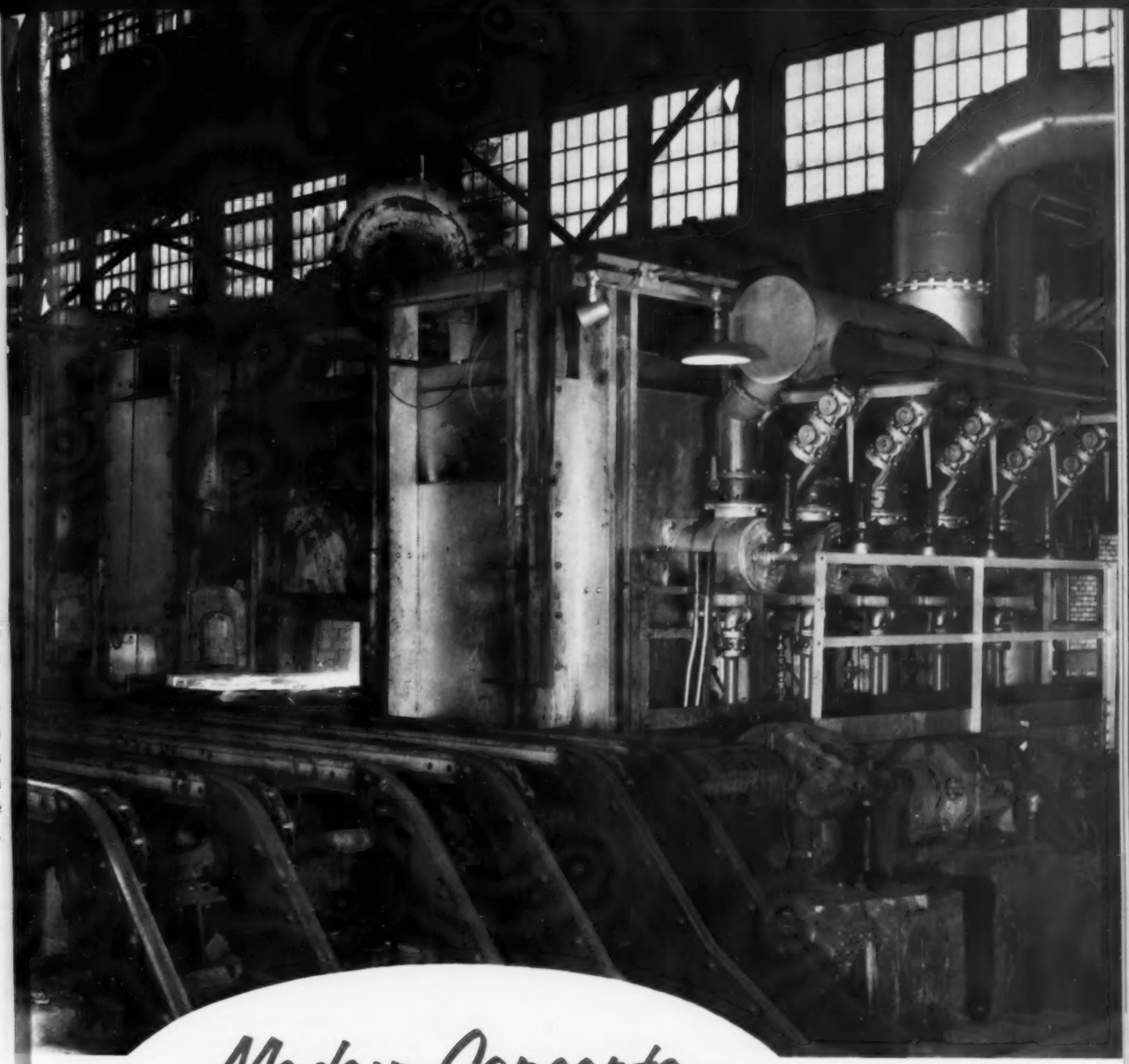


Another Loftus Continuous Heating Furnace recently installed in a Japanese Steel Plant. This furnace is used for heating steel slabs 4½" x 24" x 13' 6" to rolling temperature. *Slabs are heated from cold to 2360° F. in 1½ hours.* Furnace is equipped with two zone top and bottom oil-fired burners. Two built-in recuperator cells of 5,000 square feet total heating surface preheat the combustion air. This furnace was designed to achieve the highest possible heat recovery due to excessively high fuel cost in Japan.

A consultation with Loftus engineers may pay big dividends . . .

Call or Write Today!

- **Continuous Heat Treating Lines for Ferrous and Non-ferrous Metals**
- **Open Hearth Furnaces**
- **Ingot Heating Furnaces**
- **60-Cycle Induction Heaters for Ferrous and Non-ferrous Metals**

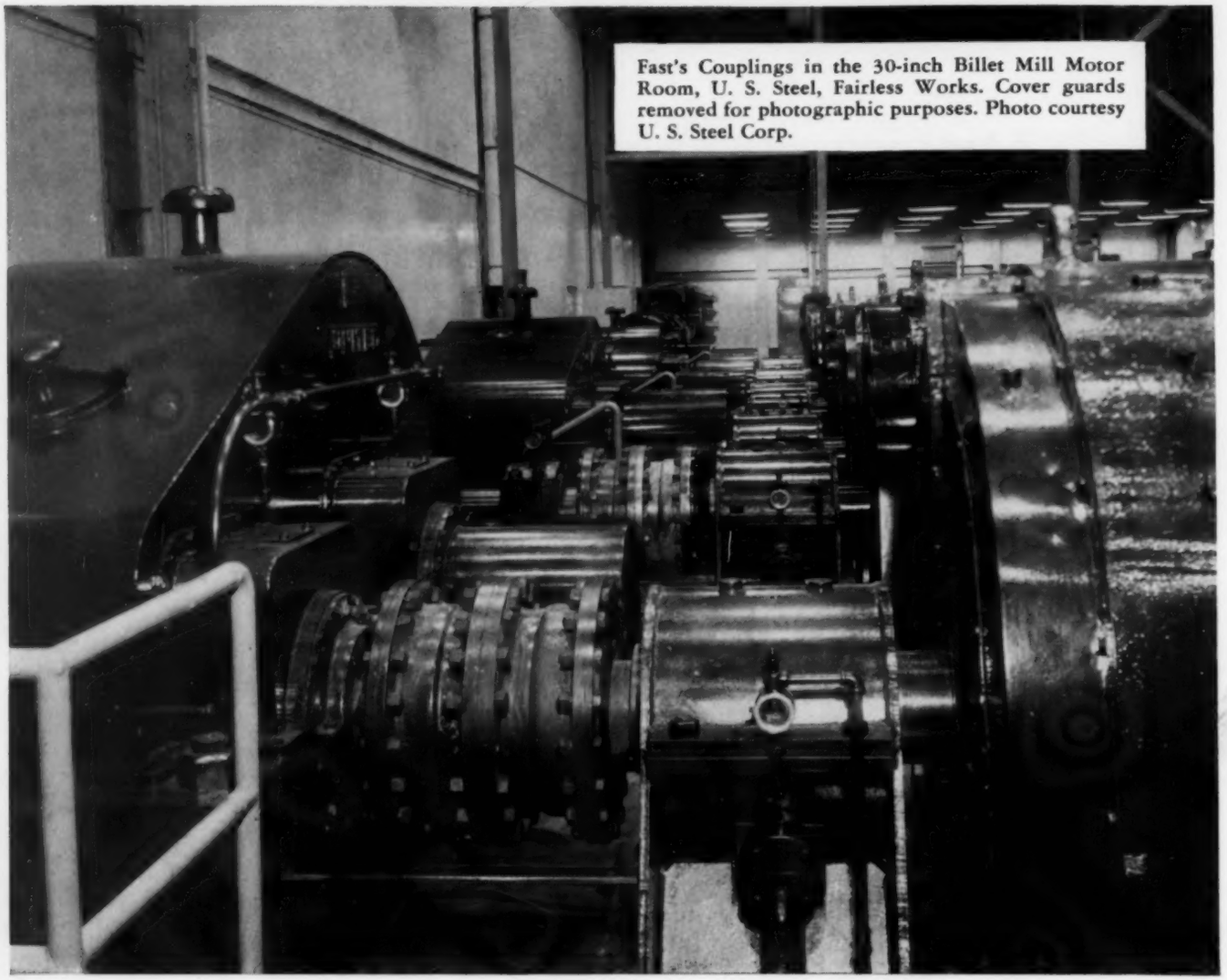


(Courtesy of Crucible Steel Company)

Modern Concepts in Continuous Heating

Loftus ENGINEERING CORPORATION
Designers and Builders of Industrial Furnaces

610 Smithfield Street, Pittsburgh 22, Pennsylvania



Fast's Couplings in the 30-inch Billet Mill Motor Room, U. S. Steel, Fairless Works. Cover guards removed for photographic purposes. Photo courtesy U. S. Steel Corp.

U. S. Steel's Fairless Works equipped with Fast's Couplings

When U. S. Steel equipped its new Fairless Plant they selected Fast's Couplings for installation.

It's no wonder that U. S. Steel specified Fast's. Fast's Couplings have the approval of industry in general everywhere.

Industry finds that Fast's Couplings minimize down-time. Fast's, *the original gear type* couplings, give trouble-free performance. Save on maintenance. Save money (often thousands of dollars in production losses) because there is no down-time due to breakage or expensive replacement of perishable parts.

They also offer the lowest cost per year . . . usually outlast the equipment they connect. Many still in use after 30 years. Why? Because they are ruggedly constructed of the sturdiest, most practical materials . . . all steel in construction, unique in design.

35 years of experience in developing these materials and designs means our staff is well prepared to give you the most effective and cost-saving solutions to your coupling problems. Let Koppers help you. Just write, outlining your requirements. And mail the coupon below for additional general information.

KOPPERS

THE ORIGINAL **FAST'S Couplings**

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.
Engineered **Products Sold with** *Service*

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* **219 Scott St., Baltimore 3, Md.**
Gentlemen: Please send me a Free, Fast's Coupling Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

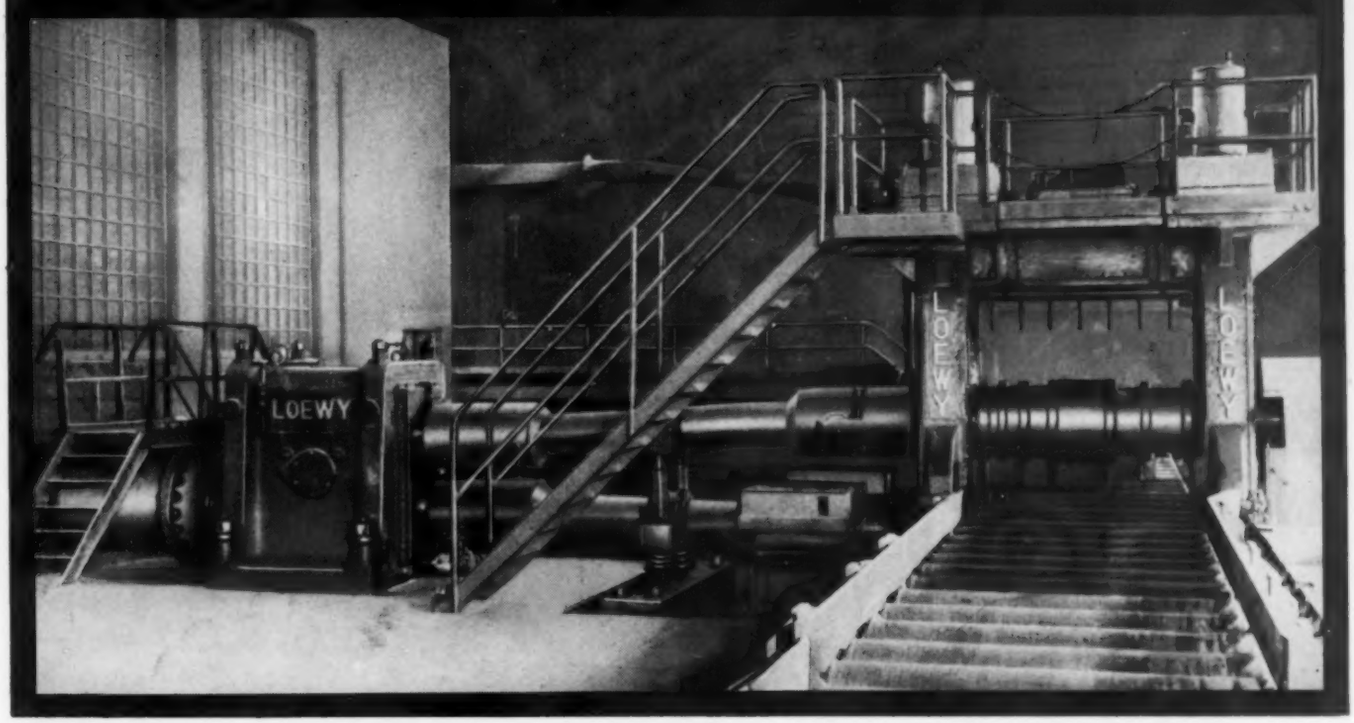
Company.....

Address.....

City.....Zone.....State.....

26" Three-high Blooming Mill Stand, part of a complete Blooming, Slabbing, Structural, Wire Rod and Strip Mill.

WE BUILD COMPLETE ROLLING MILL INSTALLATIONS



26" Two-high Blooming Mill, part of a complete Blooming, Slabbing, Structural and Strip Mill Installation.

THREE-HIGH OR TWO-HIGH BLOOMING MILLS
CONTINUOUS STRIP MILLS • SPECIAL MILLS
CONTINUOUS MERCHANT AND WIRE-ROD MILLS
MERCHANT MILLS • RAIL AND STRUCTURAL MILLS
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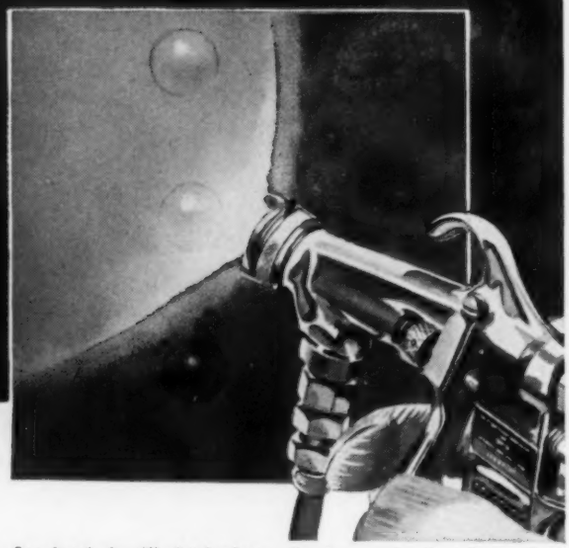
STOP RUST!

with

RUST-OLEUM®

Beautify As You Protect

Simply brush Rust-Oleum 769 Damp-Proof Red Primer directly over the rusted surface after scraping and wire-brushing to remove rust scale and loose rust. Rust-Oleum's specially-processed fish oil vehicle penetrates rust to bare metal—saving time, money, and metal! Then—beautify as you protect with Rust-Oleum's brilliant array of finish coatings. Specify Rust-Oleum for new construction, maintenance, and re-modeling. See Sweet's for complete catalog and nearest Rust-Oleum Industrial Distributor, or clip coupon to your letterhead . . . and mail today.



ABOVE: Applying Rust-Oleum 769 Damp-Proof Red Primer Over Rusted Surface After Scraping and Wire-Brushing to Remove Rust Scale and Loose Rust.

AT RIGHT: Applying Rust-Oleum Gray (One of Many Rust-Oleum Colors for Rust Prevention and Decorative Beauty).

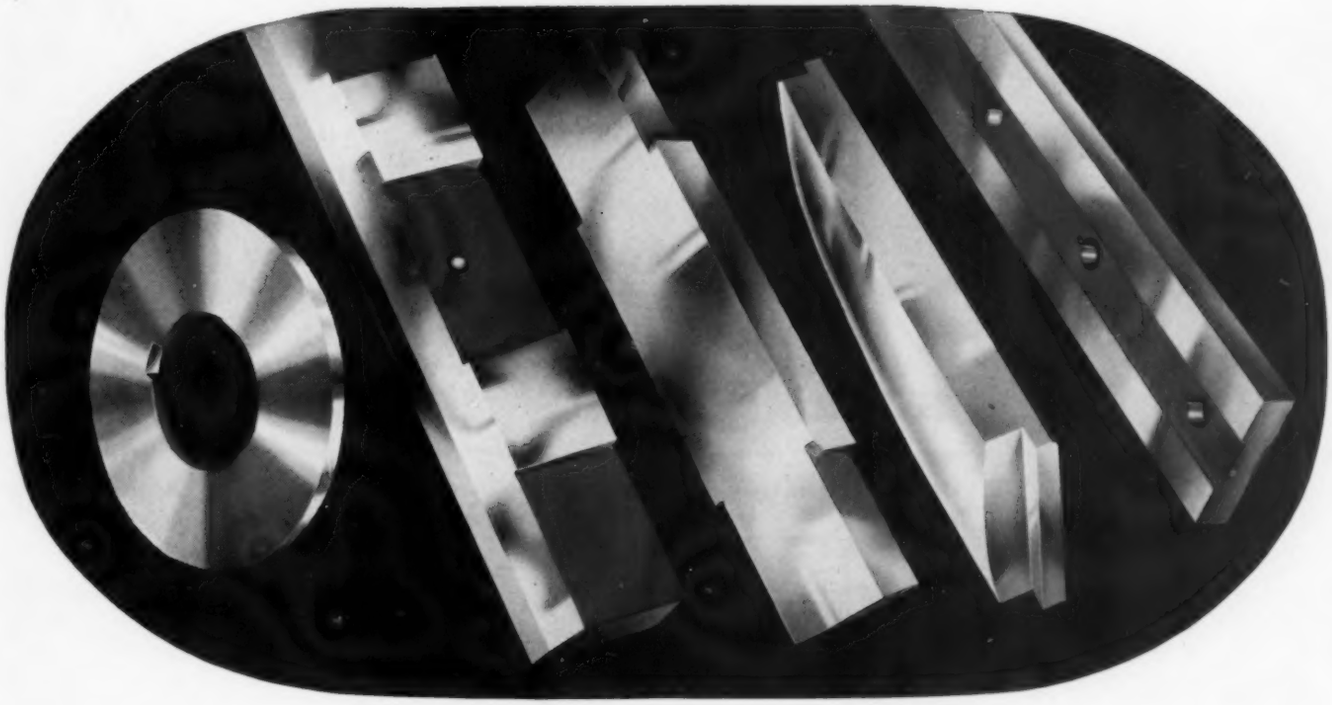
There is only one Rust-Oleum. It is distinctive as your own fingerprint.

See local classified telephone directory under Rust Preventives or Paints for nearest Rust-Oleum Industrial Distributor.

ATTACH TO YOUR BUSINESS LETTERHEAD AND MAIL TO:
Rust-Oleum Corporation, 2444 Oakton St., Evanston, Ill.

- ☐ Please Show Me the Rust-Oleum "Rusted Panel Demonstration."
- ☐ Test Application of Rust-Oleum Over Rusted Metal Surfaces in My Plant.
- ☐ Complete Literature with Color Chart.
- ☐ Nearest Rust-Oleum Industrial Distributor.

always get the OK



In mills and fabricating plants all over the country OK Machine Knives and Wear Plates, made by the Ohio Knife Co., always get the OK, because they have proved their ability to last longer in rugged service . . . with resulting production cost savings.

OK Machine Knives and Wear Plates are designed and manufactured to do the job better, more easily and more economically. For more information write Dept. 28—Z

There are definite reasons for the superiority of OK products:

1. **Only the finest tool steel is used conforming to our exacting metallurgical standards.**
2. **Our exclusive heat treating process assures the proper uniform hardness and temper to best suit your individual cutting or wear problems.**
3. **Precision grinding of all pieces to ±.00025 or less if you require.**

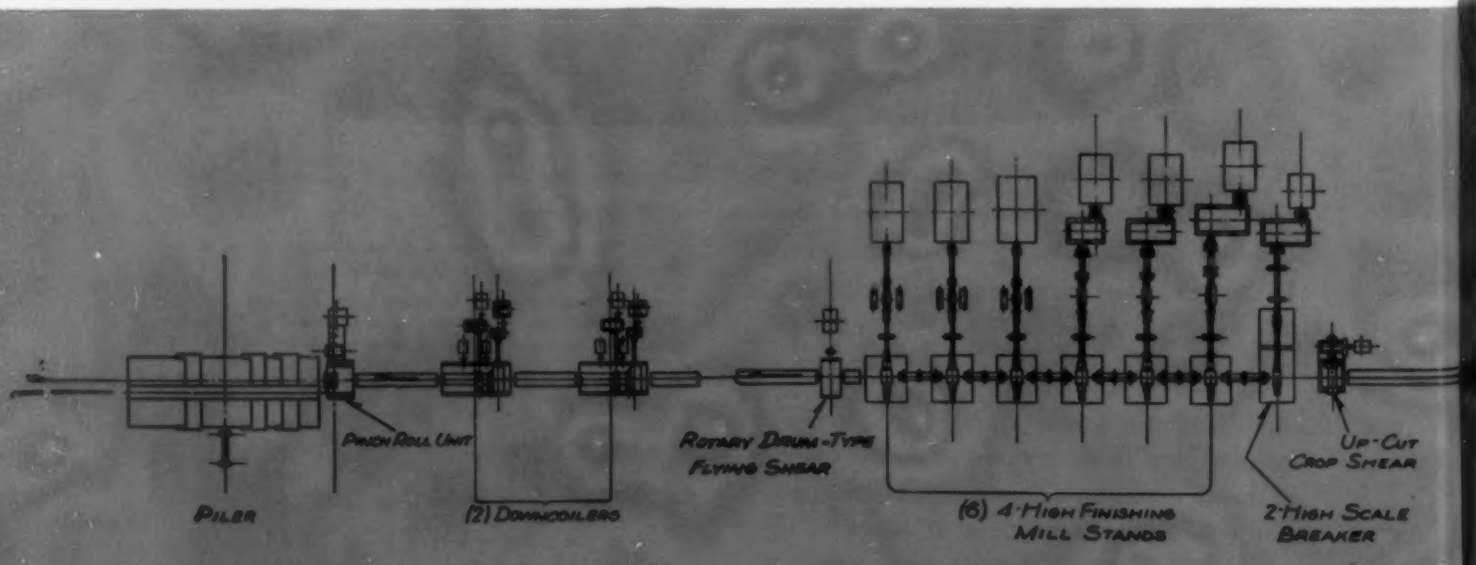
THE OHIO KNIFE CO.

CINCINNATI 23, OHIO

BLAW-KNOX

LEWIS CONTINUOUS

LEWIS PRODUCTS: Two-High Mills • Three-High Mills • Four-High Mills • Strip Mills • Bar, Billet and Structural Mills • Plate Mills • Rod Mills • Coilers • Tables • Shears • Pinion Stands • Gear Drives • Roll Lathes



produces hot rolled strip used in wide range of products

This versatile Lewis Continuous Hot Strip Mill is rolling out strip in a wide range of widths and gages . . . and of suitable chemical and physical properties to be used in a variety of products. These range from automotive parts, building hardware, household utensils, and cutlery to tin plate for packing food products.

Designed for straight line operation, from heating furnace to run-out tables, as shown in the drawing. Adapted for production of both cut sheets and coils. Two down coilers of completely new design produce a very tight and even coil.

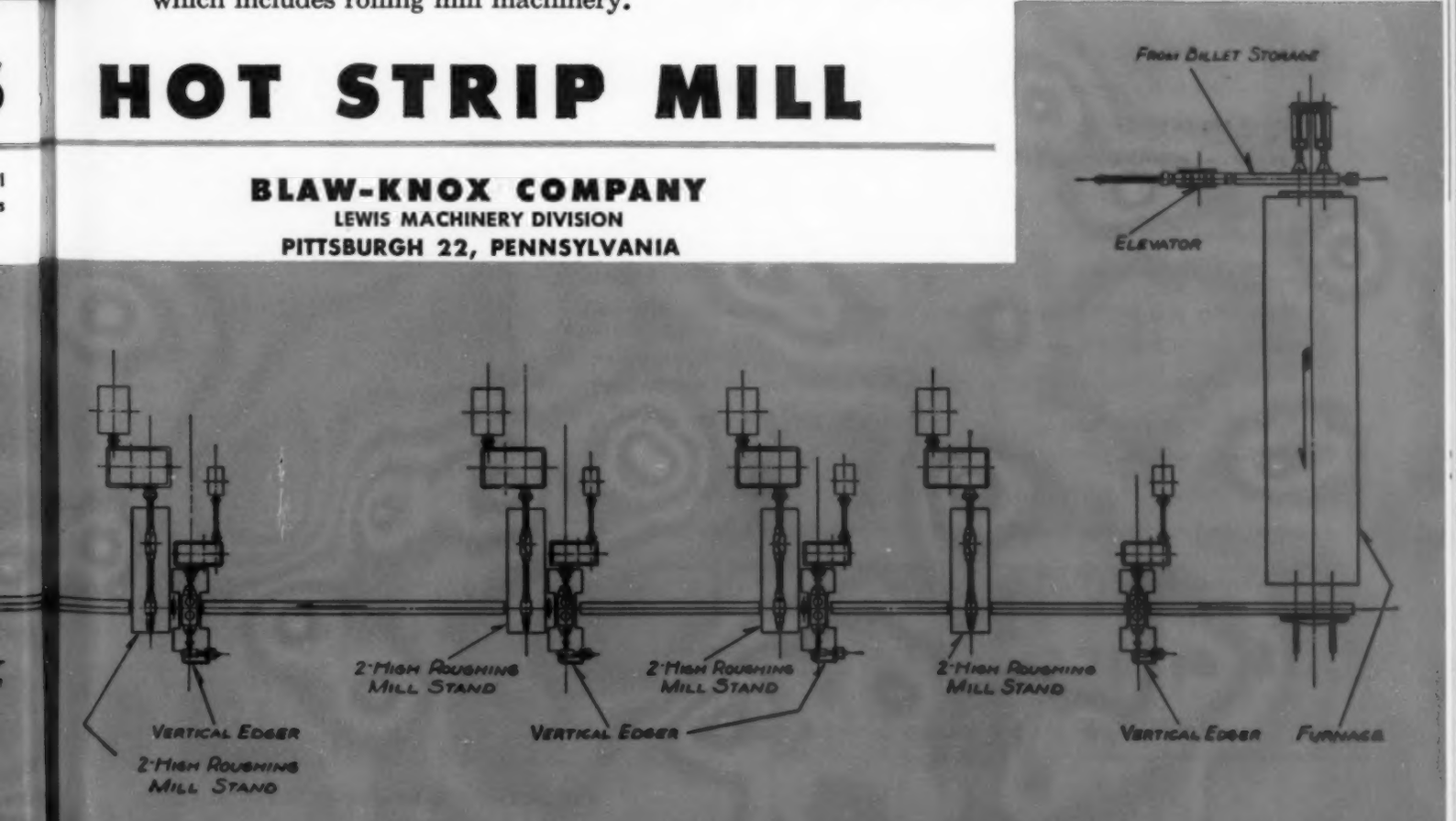
If increased production is desired in the future, a second furnace would readily double the present production. And an additional horizontal stand can be easily installed in space provided between No. 1 vertical edger and No. 1 horizontal stand.

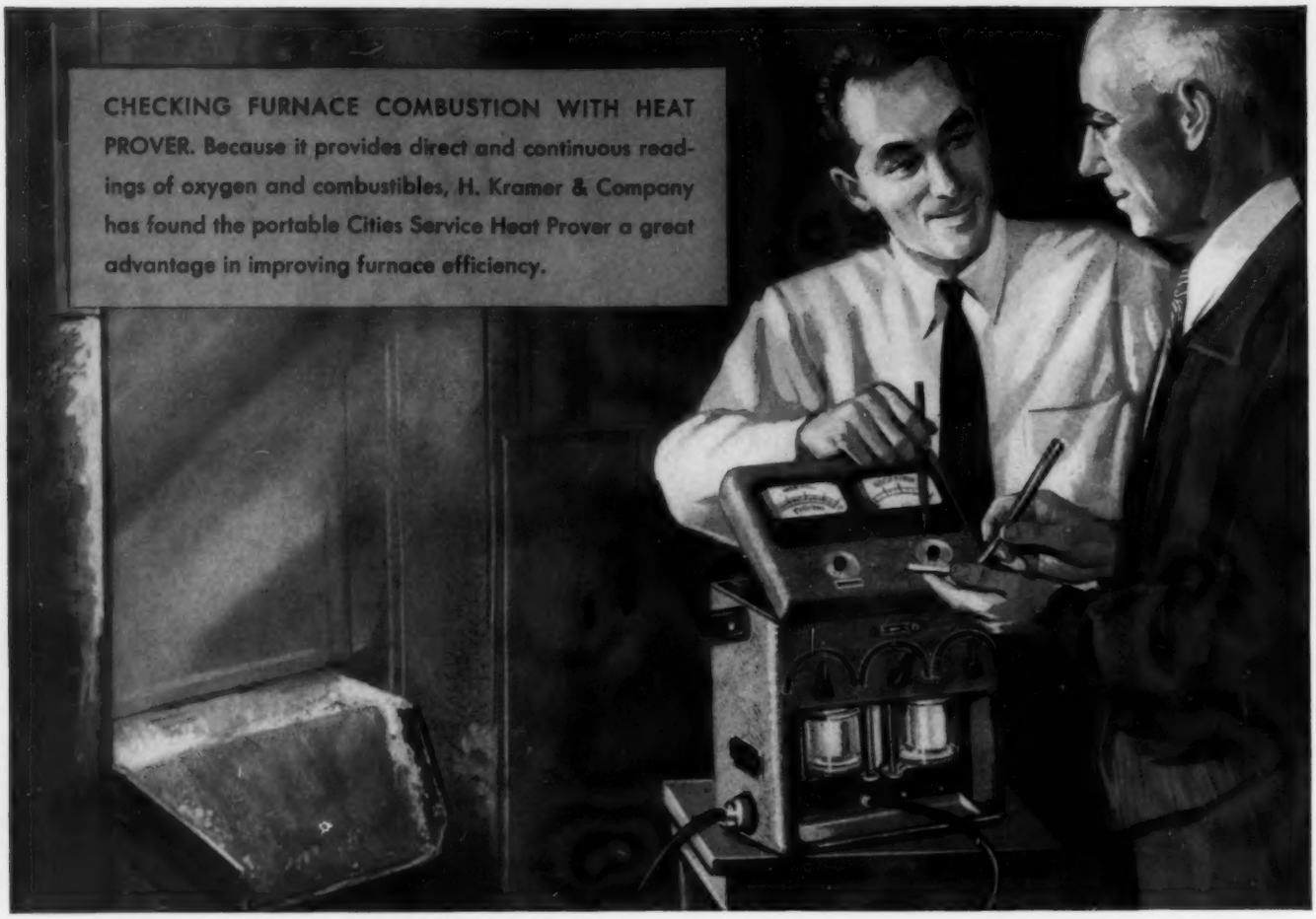
The effective performance of the Lewis Continuous Hot Strip Mill is another example of how our engineers fully understand the most intimate details of mill practice. Their practical experience and engineering know-how enable them to design sturdy mill machinery to meet specific job requirements.

Our experienced engineering staff and modern manufacturing facilities are always readily available to help you with any problem which includes rolling mill machinery.

HOT STRIP MILL

BLAW-KNOX COMPANY
LEWIS MACHINERY DIVISION
PITTSBURGH 22, PENNSYLVANIA





CHECKING FURNACE COMBUSTION WITH HEAT PROVER. Because it provides direct and continuous readings of oxygen and combustibles, H. Kramer & Company has found the portable Cities Service Heat Prover a great advantage in improving furnace efficiency.

"REDUCED MELTING TIME, INCREASED METAL RECOVERY WITH CITIES SERVICE HEAT PROVER!"

A Report From H. Kramer & Company:

H. Kramer & Company operates brass and bronze ingot smelting and refining plants in Chicago, Los Angeles, and Philadelphia, in addition to offices in most major cities.

Writes Foundry Metallurgist, Fred L. Riddell: "We wish to thank the Cities Service Oil Company for the Heat Prover service they have given us.

"Fuel savings have been substantial, but only incidental to the reduced melting time and considerable increase in metal recovery which afforded greater control over the quality of our product.

"In addition, use of the Heat Prover, has educated our foundry personnel to the point where they are satisfied with only the best operating conditions of all our melting units."

The portable Heat Prover, supplied and maintained free by Cities Service, can help achieve similar results for your furnace operation. For information, contact your nearest Cities Service representative or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

FREE—NOT AN INSTRUMENT YOU CAN BUY, BUT A SERVICE WE SUPPLY!

SEE THE HEAT PROVER IN ACTION at the Cities Service Exhibit at the Iron and Steel Exposition, Cleveland Auditorium, Sept. 28-Oct. 1. Booths 483 and 484.

Ross Carrier takes tote boxes of castings to heat treat

How The Shoemaker's Children Got Shoes, or

How we followed our own advice and saved $6000 a year

We recently put a Clark-Ross Carrier to work at our own Axle and Housing Division (Buchanan, Michigan) and saved ourselves $6000 a year. Here's the background:

Our Buchanan plant is an integrated manufacturing operation, but it's spread out over a large area. Long ago we established a central transportation area to integrate the flow of materials to the outlying departments—foundry, shaft, wheel, heat treat, etc. All parts and assemblies are put in tote boxes or palletized for storage in the central area until they are needed in manufacturing or shipping. Previously all the materials were shuttled around to the various departments on a trailer-train. A tractor and driver, a flagman and 28 trailers were required for the job. It was slow, costly in terms of manpower and trailer maintenance, and often caused damage to the loads.

The Carrier replaced these and other trailers.

Then we put the Series 70 Carrier (10,000 lbs. capacity) to work. It eliminated the whole trailer-train, which had cost us $2800 a year in maintenance. It eliminated the need for a brakeman—the Carrier is strictly *a one-man operation*. Its big pneumatic tires cushion the load, have eliminated virtually all damage to in-transit materials. At 25 mph, it runs rings around the old system, handles some 3,333,000 lbs. of material per 20-day work month.

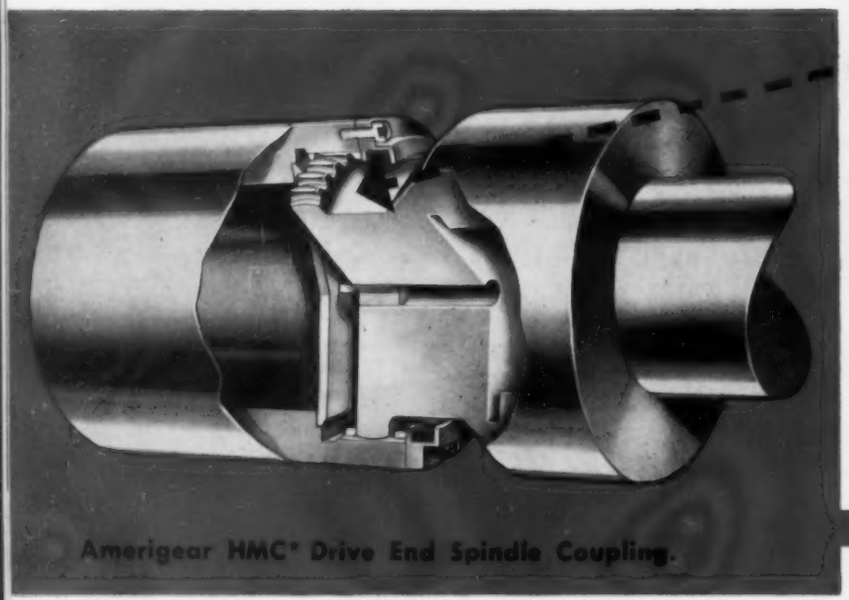
Why not look up the name of your local Clark dealer in the Yellow Pages and ask him about the unique advantages of a carrier-handling system: one-man operated, self-loading (3 seconds), capacities up to 45,000 lbs., travel speeds to 56 mph. Speaking from personal experience, we recommend the Clark-Ross Carrier highly!

See us at the '54 Iron & Steel Exposition

CLARK EQUIPMENT

ROSS CARRIER LINE
Industrial Truck Division
CLARK EQUIPMENT COMPANY
Benton Harbor 135, Michigan

SPINDLE DRIVES Between Rolls and Pinions Obtain Optimum Operating Efficiency With *Amerigear*® High Misalignment Capacity* Gear-Type Couplings Having Patented Tooth Form Teeth



Amerigear HMC* Drive End Spindle Coupling.

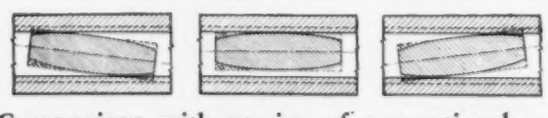
4-Hi Bliss Reversing Cold Reduction Mill equipped with Amerigear HMC* Roll Drive Spindle Couplings; operating at 125 H.P. to 750 H.P., 91 to 250 R.P.M. Max. angle no load ± 4° max. angle full load ± 2°.

AMERIGEAR High Misalignment Capacity Gear-Type Couplings operate at much higher speeds, require less space, and greatly *reduce the maintenance cycle* over that of conventional type spindle roll drives. The torque load is carried on flanks of Patented Tooth Forms rather than on tooth ends. In Amerigear HMC* Couplings the engaging roll end coupling teeth are specifically modified *for quick assembly and disassembly, thus greatly reducing down time for roll changes.*

Patented Tooth Forms incorporated in Amerigear HMC* Couplings are produced from various types of steels, heat treated and hardened, depending upon operating conditions.

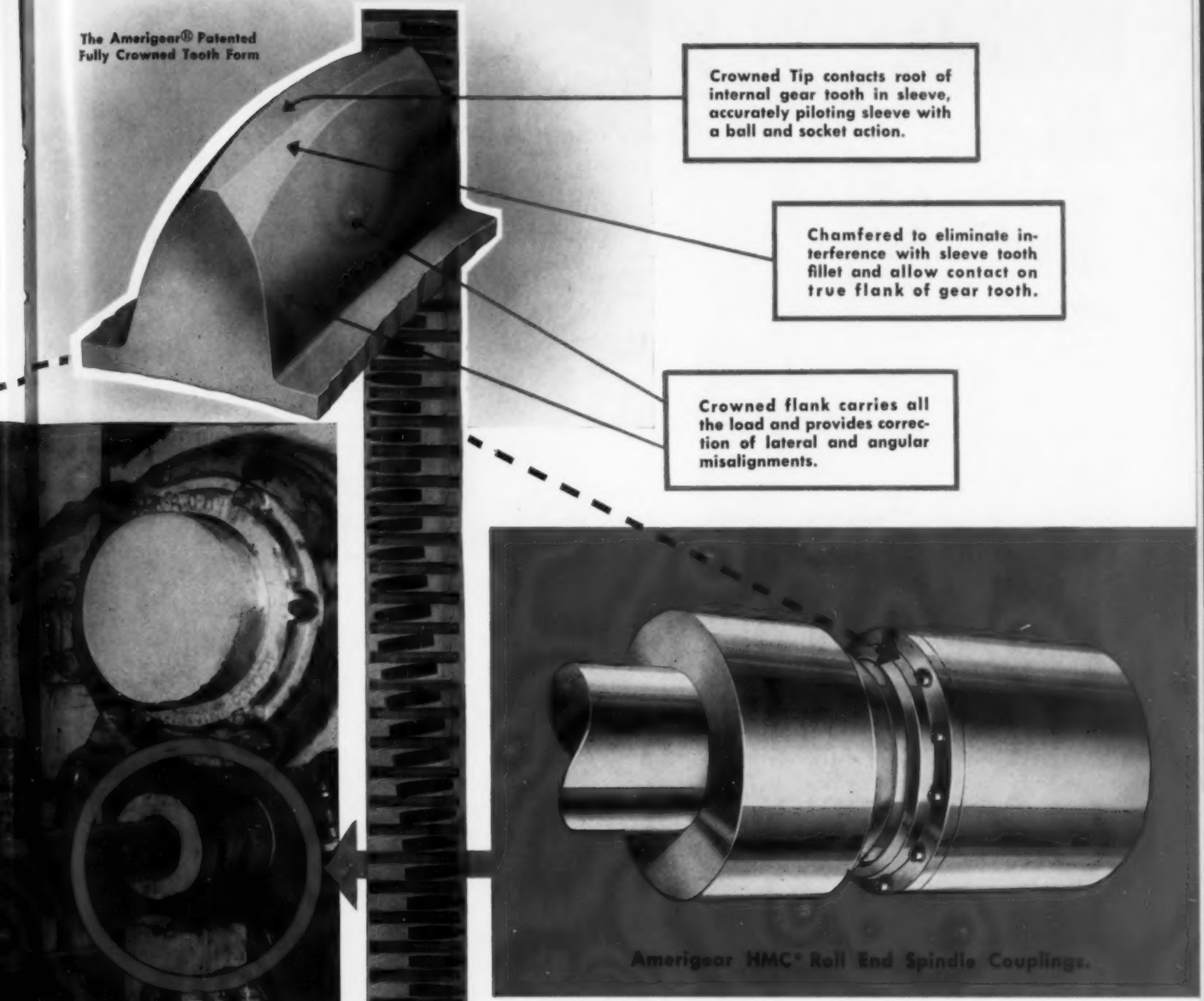
Amerigear Engineers are available to assist in *engineering special applications* and for adapting Amerigear Standard Type Couplings to solve your power transmission problems. Write for Catalog 501 and Bulletin 1052, or attach coupon to your business letterhead.

Copyright 1954



Comparison with gearing of conventional gear-type couplings shows how the Patented Amerigear Tooth Form eliminates *tooth end loading* and simultaneously allows for higher misalignment capacity for both lateral and angular misalignment. Dotted lines indicate gear teeth of conventional gear couplings.

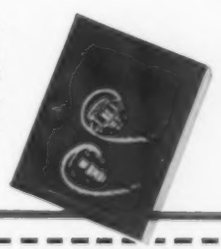
VISIT OUR EXHIBITS AT BOOTHS 284-285


The Amerigear® Patented Fully Crowned Tooth Form
Crowned Tip contacts root of internal gear tooth in sleeve, accurately piloting sleeve with a ball and socket action.
Chamfered to eliminate interference with sleeve tooth fillet and allow contact on true flank of gear tooth.
Crowned flank carries all the load and provides correction of lateral and angular misalignments.

Illustrating Full Cycle Misalignment Pattern of Amerigear H.M.C.* Patented Tooth Form.

Amerigear HMC* Roll End Spindle Couplings.

All parts of Amerigear HMC* Flexible Couplings are Parco Lubrite processed for increased wear and corrosion-resistance. The assembled coupling is essentially a dust and moisture-proof unit due to positive hub oil seals. The oil seal assures continuous operation for years with the original lubricant.



Amerigear®

HMC* FLEXIBLE COUPLING

One of several Standard Types embodying the Patented Amerigear Tooth Form
Patented and Patents Pending

AMERICAN FLEXIBLE COUPLING COMPANY
ERIE, PA., U. S. A.

ZURN

Affiliate: J. A. Zurn Mfg. Co.

SALES OFFICES IN PRINCIPAL CITIES OF THE WORLD

In Canada: Canadian Zurn Engineering Ltd., 2052 St. Catherine St., W., Montreal 25, P.Q.

AMERICAN FLEXIBLE COUPLING COMPANY
ERIE, PA. U.S.A.

Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name ..... *Title* .....

Company .....

Address .....

City ..... *Zone* ..... *State* .....

Please attach to your business letterhead. Dept. ISE 617

DRAVO CRANE CAB COOLERS

DRAVO

Here's a **CRANE CAB COOLER** *that is dependable!*

See how DRAVO can solve your industrial air conditioning problems

You'll learn . . .

—how Dravo cooling and conditioning equipment improves the productivity of your overhead cranes . . . makes crane operators more alert and efficient . . . reduces crane down time.

—that Dravo equipment can handle any conditioning or cooling problem where fumes, sand, dust, dirt or intense heat create an unhealthy atmosphere for crane operators.

You'll see . . .

—both the Dravo Self-Contained and Split-Type Crane Cab Conditioners . . . designed in a variety of models to fit any type crane.

—the Pulpit Air Conditioner, ideal for blooming mill, strip mill, rod mill and many other industrial applications.

—various models of the Dravo Conditioners to install inside the cab for heating and ventilating.

Take time . . . —to visit the Dravo Exhibit at Booth 230-231 in the Arena. You'll be glad you did!

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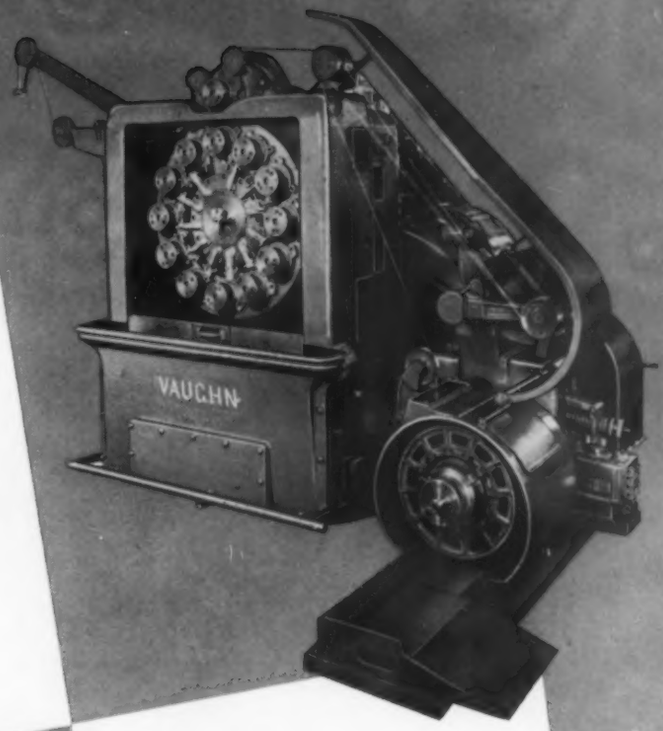
THE ONLY MANUFACTURER
BUILDING A COMPLETE LINE OF

Tandem Machines

FOR DRAWING NON-FERROUS WIRE
(ALUMINUM, COPPER, ALLOY)



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FOR COARSE WIRE

"Quick on the Draw!"

Vaughn Tandem Machines provide modern speed and versatility in drawing non-ferrous wire, combined with the engineered dependability that reflects Vaughn's many years of specialization in this field. Details? Gladly—at your convenience.

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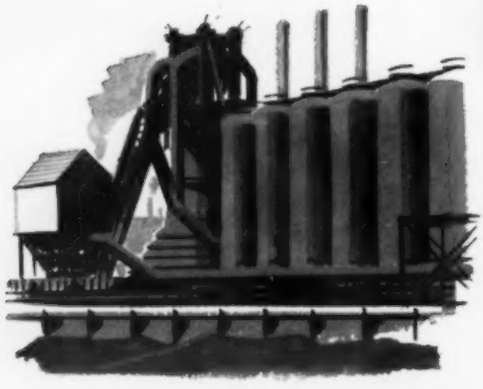
COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

HAGAN

AIR-OPERATED CONTROLS

The many successful installations of Hagan Air-Operated Controls and Hagan Ring Balance Instruments demonstrate Hagan leadership in the steel industry. These applications emphasize the versatility of Hagan Control and Instrumentation.

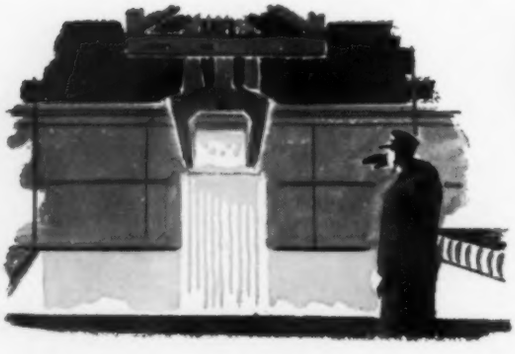


BLAST FURNACES

Blower delivery control on volumetric or constant weight basis · Pressure and temperature compensated air flow meters · Air distribution control · Bleeder valve control · Gas distribution metering and control · Flow meters for water, steam · Stove burner gas input and gas-air ratio control.

OPEN HEARTH AND HEATING FURNACES

Total heat input control and fuel-air ratio control for single or multiple fuels · Furnace pressure control · Oxygen flow metering and control · Fuel and air reversal control · Btu meters for gas firing · Draft and pressure recorders · Flow metering for steam, oil, gas or water.



SOAKING PITS

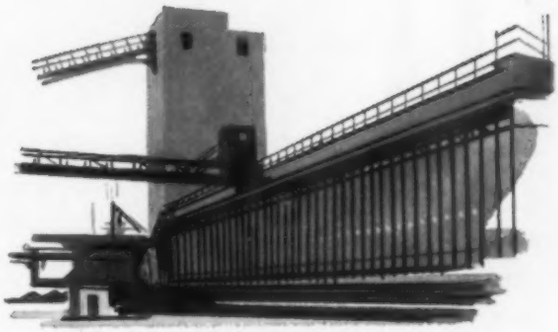
Fuel input control · Fuel-air ratio control · Reversal control · Gas pressure control · Furnace pressure control · Waste gas flue draft control · Draft and pressure recorders · Flow metering for steam, oil, gas or water.

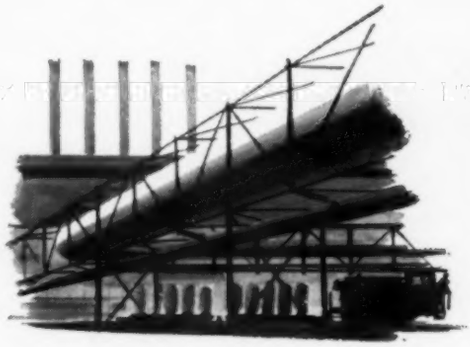
HAGAN

RING BALANCE INSTRUMENTS

COKE OVENS

Exhauster and booster controls · Collecting main pressure control · Stack draft control · Underfiring gas pressure control · Flow and draft and pressure recorders.



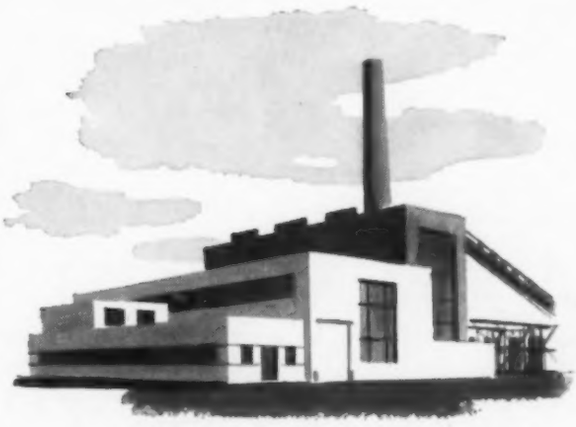


GAS DISTRIBUTION SYSTEMS

Gas mixing stations · Gas pressure control · Sequential distribution control · Pressure stabilization control · Gas flow meters—with automatic compensation for pressure and temperature · Btu meters.

BOILER HOUSES

Steam pressure control · Automatic control of single or multiple fuel input, firing separately or simultaneously · Control of load distribution · Fuel-air ratio control · Furnace draft control · Boiler drum water level control · Flow metering for steam, oil, gas and water · Automatic compensation of flow readings for pressure and temperature variations · Pneumatic and electric signal transmission.



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HAGAN CORPORATION

HAGAN BUILDING · PITTSBURGH 30, PENNSYLVANIA

BOILER COMBUSTION CONTROL SYSTEMS · RING BALANCE FLOW AND PRESSURE INSTRUMENTS · METALLURGICAL FURNACE CONTROL SYSTEMS CONTROL SYSTEMS FOR AUTOMOTIVE AND AERONAUTICAL TESTING FACILITIES

THE BIG LIFT

350-TON *Alliance* LADLE CRANE HANDLING 510-TON TEST LOAD

Alliance Cranes handle the world's largest loads with ease. This 350-ton, 4-girder, 60-foot-span ladle crane, equipped with a 60/25 trolley, is one of two delivered recently to a Midwest steel company for open hearth duty. The photo shows it handling a 510-ton test load.

The 24 track wheels on the bridge are spaced to obtain equal loading on each wheel. The trolley rolls smoothly on 16 track wheels arranged to provide transverse and longitudinal equalization.

The operator's cab is air conditioned.

Alliance Cranes are as safe as they are big. They have to be. The crane pictured here is equipped with laminated ladle hooks, safety rope reeving, interlocked drums and synchronized worm drive. The hoist gearing is so proportioned that the full capacity of the crane can be lifted by one motor without exceeding the quarter-hour rating. These time-tested safety devices were developed and engineered by Alliance.

When you face your next big lifting problem, discuss it with Alliance. Alliance will help you reach an efficient, economic solution.

World's Largest Builders of the World's Largest Cranes

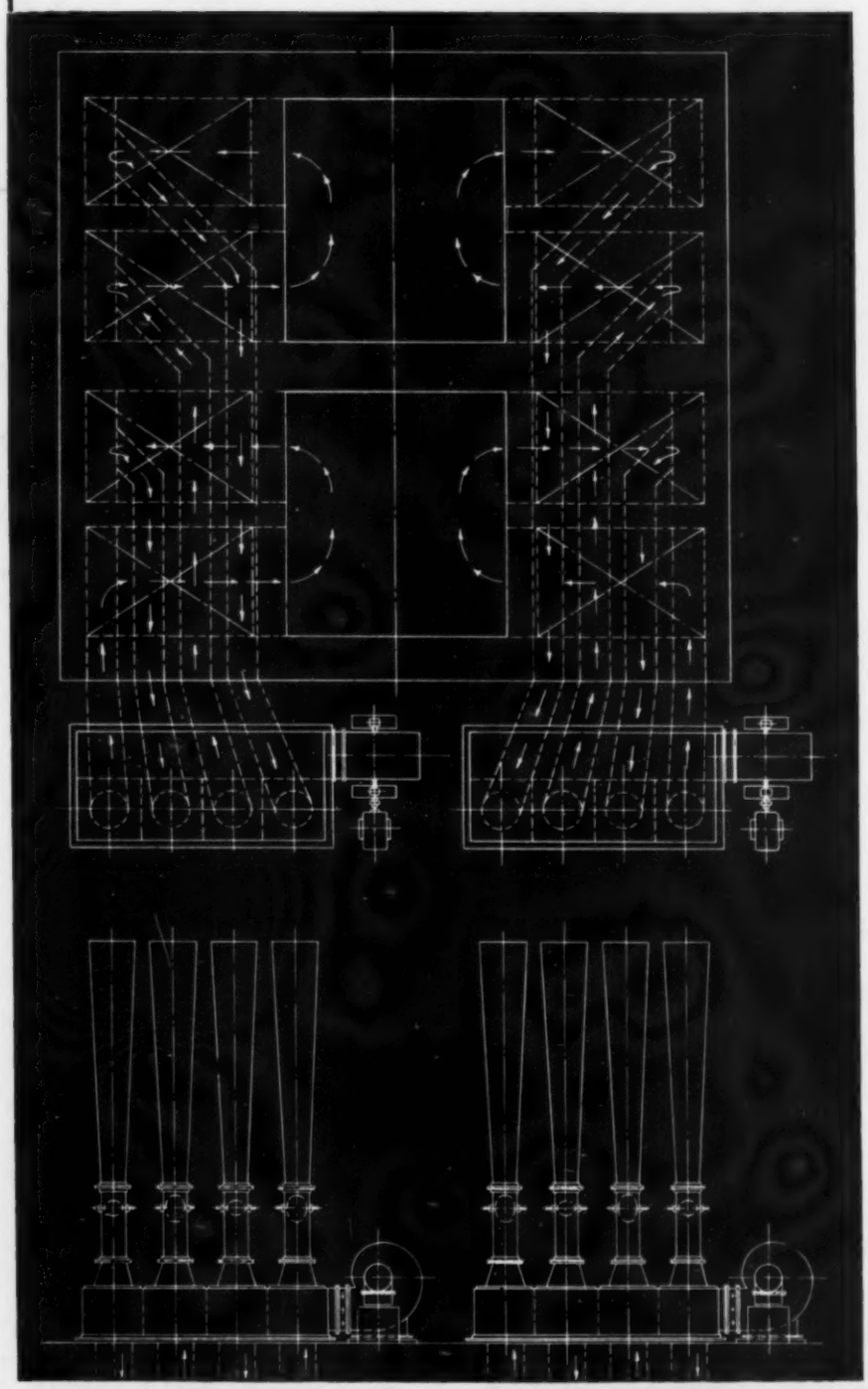
THE *Alliance* MACHINE COMPANY

Main Office: Alliance, Ohio *Founded 1901*

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS

Give Us The Runway And We'll Lift The World

MODERNIZE YOUR REGENERATIVE SOAKING PITS WITH MORGAN-ISLEY FURNACE SYSTEMS



60 holes have been modernized with eight more being built now.

The Results? 35% increase in Tons per Hour per Square Foot of hearth area with resultant decrease in heating costs.

The Cost? 58% of the cost of a new one-way fired recuperative pit. This is for an entirely new installation.

Maintenance? First pits still operating satisfactorily after three years service with original checkers.

Controls? Simple on-off temperature control and automatic reversal. No fuel air ratio or furnace pressure control required.

CCC-68

MORGAN CONSTRUCTION COMPANY WORCESTER, MASS.

ROLLING MILLS • MORGOIL BEARINGS • REGENERATIVE FURNACE CONTROLS • EJECTORS • PRODUCER GAS MACHINES

H. H. Wood, Rep., Koppers Bldg., Pittsburgh, Pa. *English Rep.*, International Construction Co., 56 Kingsway, London W. C. 2, Eng.

You can increase production at night by using Crouse-Hinds Floodlights to

"turn night-time into day-time"

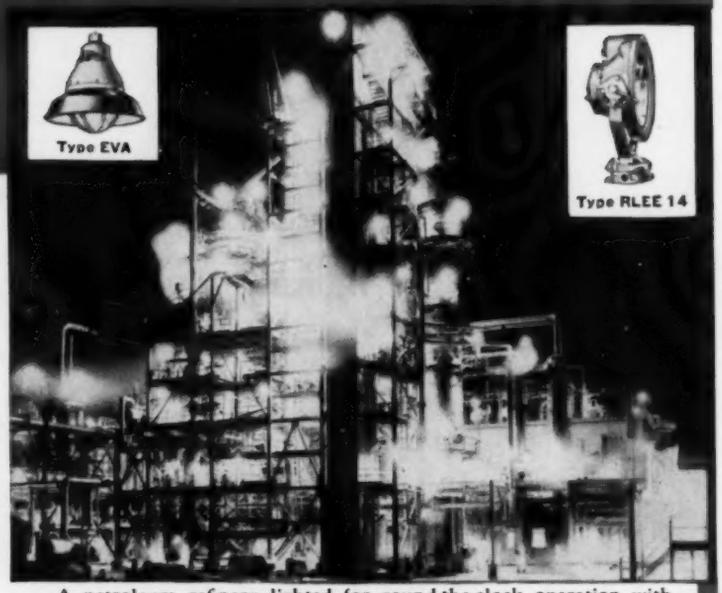
Production curves go up when Crouse-Hinds high efficiency floodlights are installed in yards and approaches to industrial plants.

The usefulness of many outdoor areas can be multiplied by flooding them with controlled illumination. Crouse-Hinds all-inclusive line with short, medium, and long range projectors makes it possible to get the right amount of light at the locations where it is needed. This control insures the clarity of daylight where it will do the most good, without wasteful over lighting of unused areas.

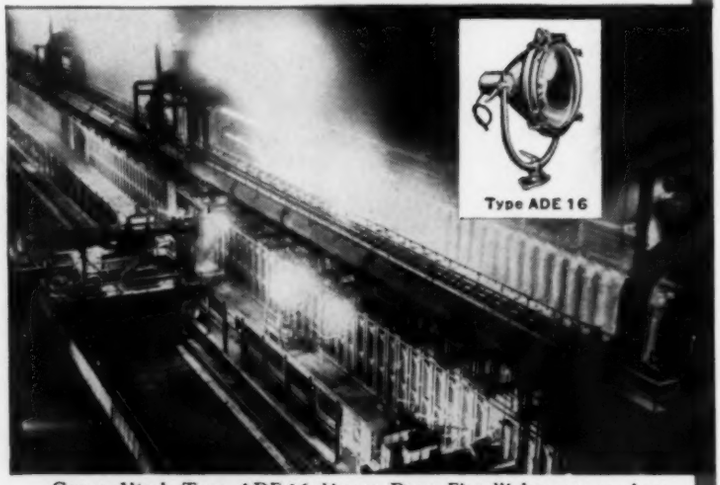
Frequently it will cost much less to project light a considerable distance with Crouse-Hinds long range floodlights than to run cable and install local lighting. There are also indoor locations in large buildings where floodlights are the most economical and satisfactory source of light.

Plenty of light is also the most reliable and cheapest form of protection against night prowlers. Sabotage and pilferage thrive in darkness. Crouse-Hinds floodlights project powerful beams of light that bathe all approaches to your property with glaring radiance, compelling everyone to be more visible than in broad daylight.

A Crouse-Hinds floodlighting installation pays off in: (1) increased production; (2) prevention of accidents; (3) protection against dangerous prowlers. Pioneers in floodlighting, Crouse-Hinds illumination engineers have accumulated a wealth of lighting knowledge that is at your service. Write for additional information and ask for your FREE copy of Crouse-Hinds Bulletin 2672 "Lighting Equipment". It contains listings of hundreds of types and sizes of floodlights and explosion-proof, dust-tight, and vaportight industrial lighting fixtures.



A petroleum refinery lighted for round-the-clock operation with Crouse-Hinds Type EVA Explosion-Proof and Raintight Industrial Lighting Fixtures, and Type RLEE-14 Explosion-Proof Floodlights.



Crouse-Hinds Type ADE-16 Heavy Duty Floodlights are used to "turn night-time into day-time" at this plant for 24-hour production.

A parking lot efficiently lighted by Crouse-Hinds Type FLA General Purpose Floodlights.

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

OFFICES: Amarillo — Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland Dallas — Denver — Detroit — Houston — Indianapolis — Kansas City — Los Angeles — Memphis Milwaukee — New Orleans — New York — Philadelphia — Pittsburgh — Portland, Ore. San Francisco — Seattle — St. Louis — St. Paul — Tulsa — Washington
RESIDENT REPRESENTATIVES: Albany — Atlanta — Baltimore — Baton Rouge — Charlotte Chattanooga — Corpus Christi — Reading, Pa. — Richmond, Va. — Shreveport
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

A Nationwide Distribution Through Electrical Distributors

FLOODLIGHTS · AIRPORT LIGHTING · TRAFFIC SIGNALS · CONDULETS

EDGE CONTROL

positions 65,000 lb. wind-up reel to deliver straight coils

This straight coil and others just like it are produced without exception on the continuous galvanizing line at the Wheeling Steel Plant in Martins Ferry, Ohio. Even though the coil and reel together weigh 65,000 lbs., the Askania Edge Position Control reacts with sufficient speed, precision and thrust to maintain the edge position within a tolerance of plus or minus .0156 of an inch.

Simple, dependable, powerful and accurate, the Askania control is the solution to the problem that previously defied control. Any mechanic can maintain it; it is self-lubricated; it incorporates only one moving part. It delivers power instantly in almost unlimited amounts for heavy loads. It is low in cost and built to take all the abuse that continuous operation in hard service can give.

In addition, Askania maintains a special abilities department, a reservoir of engineering experience, to cope with unique problems in servo or process control, or automation.

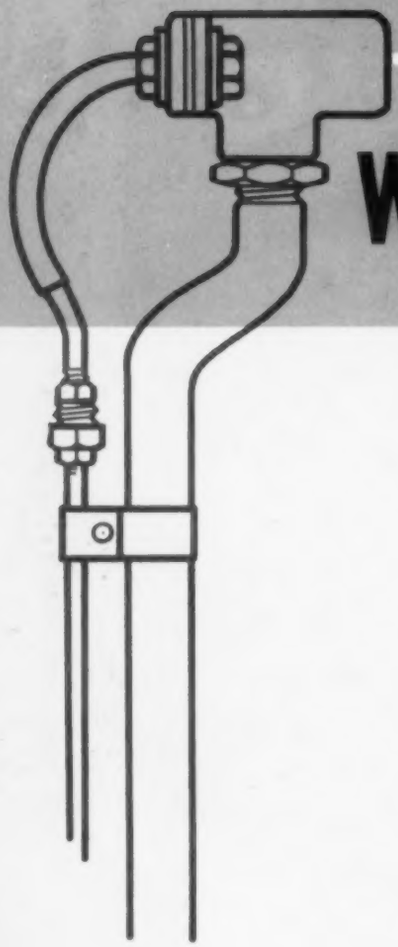
For full details, write for Bulletin 161 and 139.

ASKANIA REGULATOR COMPANY

246 E. Ontario Street, Chicago, Illinois

Subsidiary of General Precision Equipment Corp.

NOW—Koppers can repair with the silica-welding



● For the benefit of the steel industry, Koppers has brought the silica-welding process to this country. This method of repairing coke ovens has been used successfully in England for many years.

Briefly, here is the process: the surface of the silica brick that is to be welded is heated to a melting stage. Then, a welding torch and a silica sand feeder work together to apply a special sand to the damaged brickwork. Sand is sprayed—in a fused state—into pinholes, cavities and eroded areas. The completed weld is glassy, solid, free of porous structures.

With this process, coke ovens are repaired while hot. There is no need to shut down the battery; only the individual ovens being repaired are isolated. More important, repairs are permanent. The repaired wall is just as strong as the original silica brickwork.

Koppers has men who are experienced in the art of silica welding. By working with and instructing your maintenance men, they can prolong the life of your coke ovens by repairing them expertly. Your inquiry is invited. Please write to Koppers Company, Inc., Engineering and Construction Division, Pittsburgh 19, Pennsylvania.

Constructing or repairing coke ovens is just one way in which Koppers serves the steel industry. For any kind of metallurgical construction, you can count on Koppers.

KOPPERS®

Engineering and Construction Division

KOPPERS COMPANY, INC., PITTSBURGH 19, PENNSYLVANIA

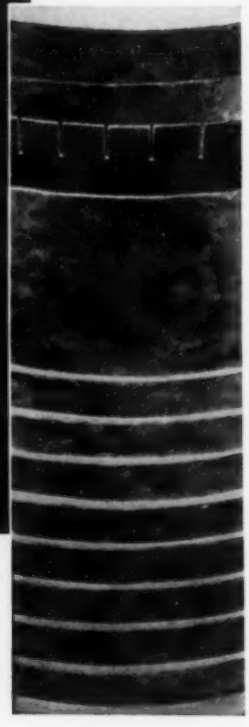
coke ovens process

CLOSE-UP of spray welding with silica sand.

COKE OVEN BEING REPAIRED by spray welding while the structure is still hot. Special silica sand is being fused to the damaged brickwork.

How special insulation protects

DEEP-DOWN PULLING POWER



Stearns uses a special mica plate for insulation around the inside diameter of the coil and between the pancake coils. Mica is laminated and consists of about nine layers of 1/32 in. molding mica. This is applied under heat and provides a very dense and hard insulation between the copper and steel. Discs between coils are also made of laminated mica and finished under pressure.

• Protect the coil and you safeguard the very heart of a lifting magnet. That is why powerful, deep-field Stearns magnets are built with extra heavy-duty coil insulation, extra protection against shorts, burn-outs, current leakage.

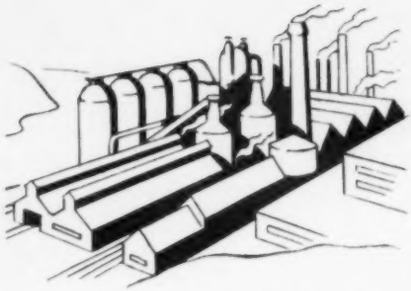
With this insulation, a Stearns lifting magnet can withstand heat generated during steady work periods — operates profitably on long-shift duty. And it's added protection when magnet is working outdoors or under excessively damp conditions.

Superior insulation is only one of the ways Stearns keeps its powerful lifting magnets in top operating condition. See your Stearns representative for all the facts, or write for Bulletin 35-B-3. 1098

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

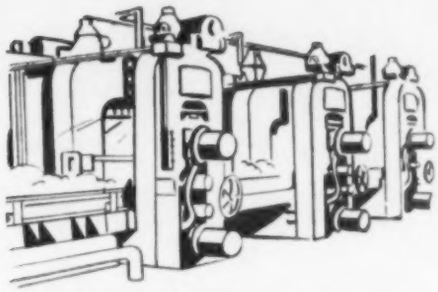
STEARNS MAGNETS

STEARNS MAGNETIC, INC. 681 S. 28th St., Milwaukee 46, Wis.

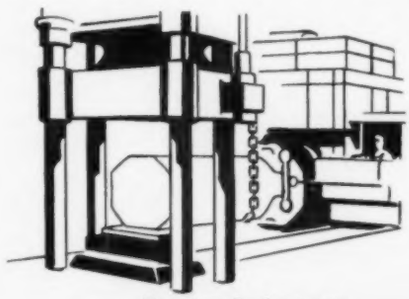


Steel Producing Plants

WHEN A *REGULAR LUBRICANT* ISN'T GOOD ENOUGH . . .



Hot Strip, Cold Reduction and Temper Pass Mills



Forging Industries

SPECIFY LEADOLENE* *Klingfast*

CHECK THESE 9 IMPORTANT FACTS:

1. **EXTREME PRESSURE pH-ilm STRENGTH** of 50,000 lbs. per square inch minimum by "Timken" testing machine.
2. **ADHESIVENESS** in which affinity for steel and other metals develops maximum adhesion and prevents drippage or creeping. Retains a flexible coating in nature.
3. **WATER REPELLENCE** which retards washing off, creates a lubricating pH-ilm under moisture or water conditions.
4. **CORROSION PREVENTION** is an excellent protective coating in that it will not etch or corrode metals. Is never acidic.
5. **COMPOUNDED STABILITY**—Will not bleed or change physical condition within range of higher than usual temperatures for this type of lubricant.
6. **LOW TEMPERATURE FACTORS**—While having a solidifying action by decreased temperature as low as —40 F., it does not harden, crack or decrease in adhesion. The flexible coating withstands distortion of the application.
7. **ABRASIVE RESISTANCE**—Extremely high for a lubricant. Does not wipe off nor will be removed in handling by workmen's hands or gloves. Is extremely repellent to adhesion of scale, metallics and other forms of dusts or contamination.
8. Klingfast has remarkable corrosive resistance to salt or sea water, acidic vapors and solutions.
9. Klingfast can be removed by ordinary solvents such as kerosene, gasolene, naphtha, carbon-tetrachloride and similar substances but is highly impervious to lubricating oils and greases.

The "I.P." LUBRICANT*

On the really tough jobs in the steel industry, the answer to vastly reduced lubricating costs and extended equipment life is *Leadolene Klingfast.* Capable of withstanding pressures up to 50,000 p.s.i., this lead-base lubricant with its "indestructible pH-ilm" has proved itself repeatedly on the most difficult applications.

For efficient lubrication in the presence of water . . . for extreme adhesiveness to steel under high heat conditions . . . for unexcelled abrasion and corrosion-resistance . . . for actual cash savings up to 400 per cent—investigate the performance characteristics of *Leadolene Klingfast.*

*I. P. . . . ("Indestructible pH-ilm" lubricant)

Write for 24-page descriptive booklet

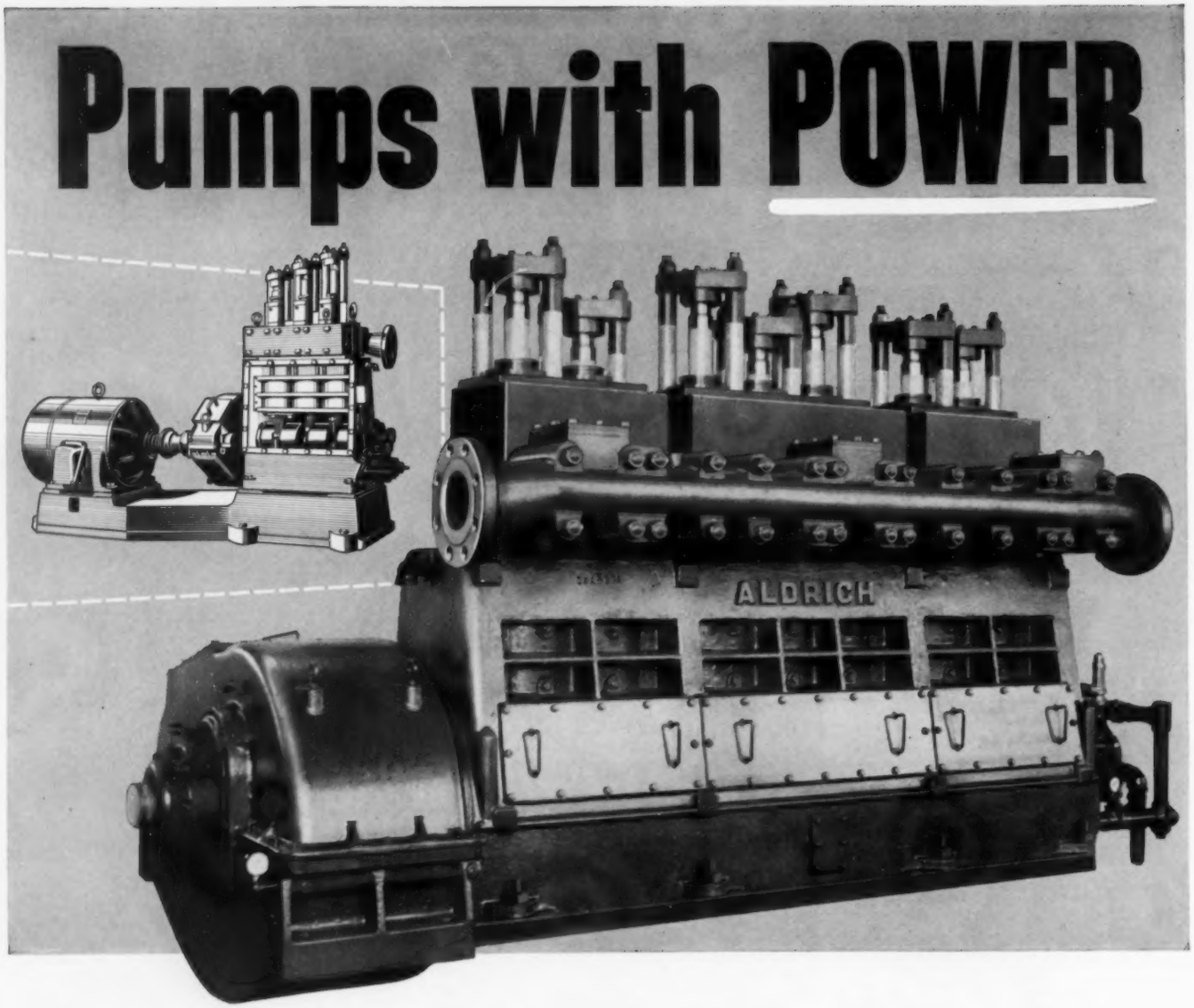
THE BROOKS OIL CO.

Since 1876

Executive Offices and Plant . . . . . Cleveland, Ohio
Executive Sales Offices . . . . . Pittsburgh, Pa.
Canadian Offices and Plant . . . . . Hamilton, Ontario
Cuban Office . . . . . Santiago de Cuba

Warehouses in Principal Cities

Pumps with POWER



Aldrich Direct Flow Pumps deliver real *power*—the kind of power that makes them ideal for a host of pumping applications throughout industry.

These power pumps are widely used on jobs like hydraulic systems for press operation; plastic and rubber molding and extrusion; die casting and steel mill descaling, and many uses in the petroleum and chemical industries.

The reason Aldrich Pumps are "extra-powered" is simple. *Higher operating speeds*—in pumps that are relatively light, small and compact—result in greater *pressures* and *volumes.*

Added power like this means more *work* from lower cost units. You'll get this basic advantage when you choose Aldrich—plus other cost-cutting features like sectionalized fluid ends . . . changeable plunger sizes . . . interchangeable moving parts . . . and reduced space requirements.

Aldrich Direct Flow Pumps are manufactured in 3″, 5″ and 6″ stroke sizes, in Triplex, Quintuplex or Septuplex models (50 to 900 hp). Pictured here are a 700 hp Septuplex and a 100 hp Triplex. For more information about Aldrich Direct Flow Pumps write for catalogs, engineering service, or a representative's call.

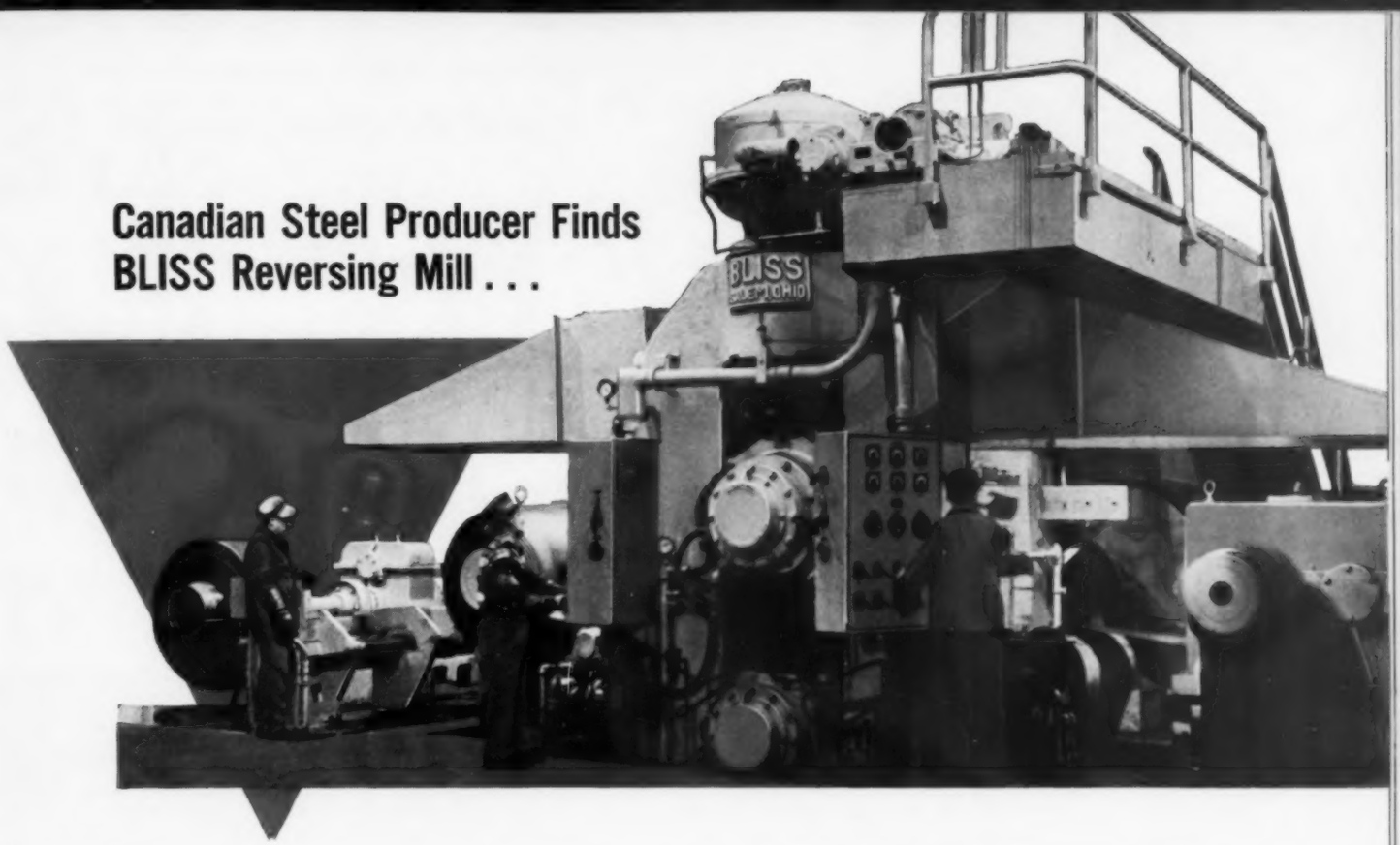
THE ALDRICH PUMP COMPANY

21 PINE STREET • ALLENTOWN, PENNSYLVANIA

. . . Originators of the Direct Flow Pump

Representatives: Birmingham • Bolivar, N. Y. • Boston • Buffalo • Carmi, Illinois • Charleston, W. Va. • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Duluth Houston • Los Angeles • New York • Oakland, Calif. • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. • Rochester • Salt Lake City • San Francisco • Seattle Somerville, Mass. • Spokane, Wash. • Syracuse • Tulsa • Washington, D. C. • Youngstown • Export: Petroleum Machinery Corp., 30 Rockefeller Plaza, New York 20, N. Y.

Canadian Steel Producer Finds BLISS Reversing Mill . . .



A mill designed and built for **RUGGED** service

Severe, short run work is the norm here; quick changeover a must. On one schedule, this mill may be rolling stainless steel; on another, mild, high carbon or silicon steel. And doing it all to standards that match our American standards in every way.

Because it was especially designed for the job, this Bliss four-high reversing mill takes the changing requirements in stride: it will roll steel . . . up to 26 inches wide . . . down to 0.010-inch gage at speeds up to 1840 fpm.

Heavy housing posts, rolls and bearings make the mill suited to any job. Valuable time is saved by taking heavier reductions per pass . . . by the ability to discharge coils at either end of the mill. Latest material handling equipment makes for safe handling during operation and changeover.

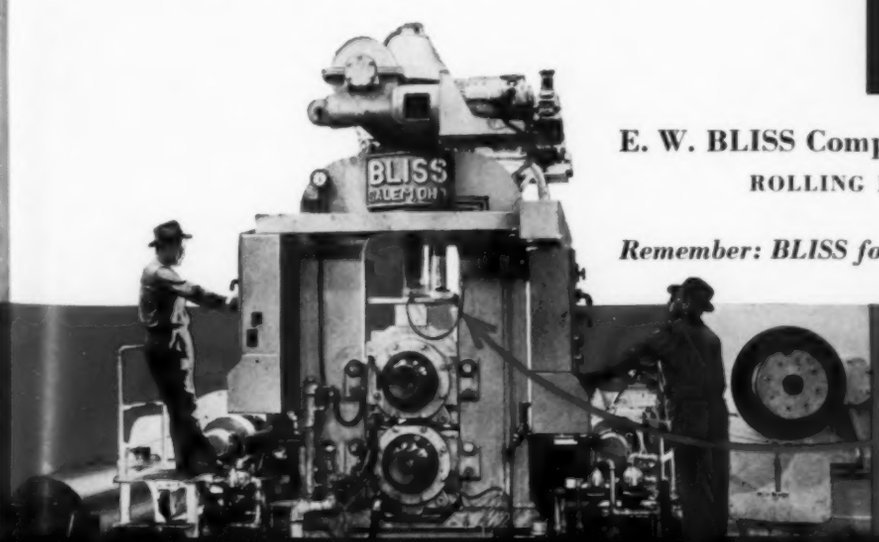
In addition, this mill features a mandrel-type payoff reel which controls back tension and strip centering to compensate for telescoped coils coming to the mill.

This four-high mill, and the *two-high temper mill shown below*, are typical results of close cooperation between mill operators with a problem and Bliss rolling mill engineers. Let these specialists help you with your problem. Learn how Bliss has helped others; write today for Catalog No. 40-A.

BLISS
SINCE 1857

E. W. BLISS Company, General Office: Canton, Ohio
ROLLING MILL DIVISION: SALEM, OHIO

Remember: BLISS for Presses, ROLLING MILLS, Special Machinery



BLISS TWO-HIGH MILL HAS TALL WINDOW to accommodate additional rolls to allow for reduction work as well. Installed in a plant of the same Canadian producer, this mill is used for temper passing and special processing.

Pouring power into a giant of steel

Dramatic symbol of America's industrial might, U. S. Steel's big Fairless Works is completely new —a giant at birth! From foundations to furnaces, here is an outstanding example of industrial foresight and planning.

Among this huge mill's many impressive innovations is its planned system of power distribution. Substations, switchgear, and circuit breakers—channeling power throughout this giant of steel—are strategically located to provide maximum protection, control, and continuity of service.

Installation of *only the finest* of equipment has been a long tradition at U. S. Steel. Electrical distribution equipment—of fundamental importance—has to be rugged and dependable to fulfill these vital requirements.

at U.S. Steel's new FAIRLESS WORKS

kilowatts for a colossus feed
through switchgear and circuit breakers built by I-T-E

Some 70 modern indoor and outdoor I-T-E Unit Substations transform and distribute power throughout the mill. I-T-E Low-Voltage and Metal-Clad Switchgear, as well as Heavy-Duty I-T-E Circuit Breakers, guard the many critical steel processes.

From the start, I-T-E gave important engineering assistance in the preparation of specifications and in expediting *switchgear* orders for the Fairless Works. As a result of this close cooperation, power distribution equipment was on the ground *when needed* to fit right in with tight construction schedules.

Traditionally a supplier of U. S. Steel, I-T-E is proud of its place as a *major* contributor of quality power distribution equipment for the new Fairless Works.

AT FAIRLESS—

I-T-E Switchgear protects:

rolling mills	**open hearths**
coke ovens	**maintenance shops**
power house auxiliaries	**office building**
billet mills	**car dumper**
strip mill	**ore dock**
blast furnaces	**oil bulk storage**

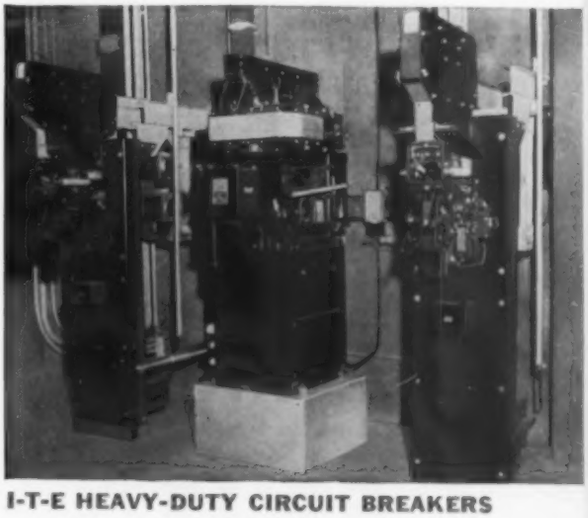
For details, contact the I-T-E field office nearest you. Look in your classified directory under "Electric Equipment."

I-T-E METAL-CLAD SWITCHGEAR

installed in cold mill for 2400-volt distribution.

I-T-E LOW-VOLTAGE SWITCHGEAR

installed in sheet and tin mill for 480-volt distribution.



I-T-E HEAVY-DUTY CIRCUIT BREAKERS

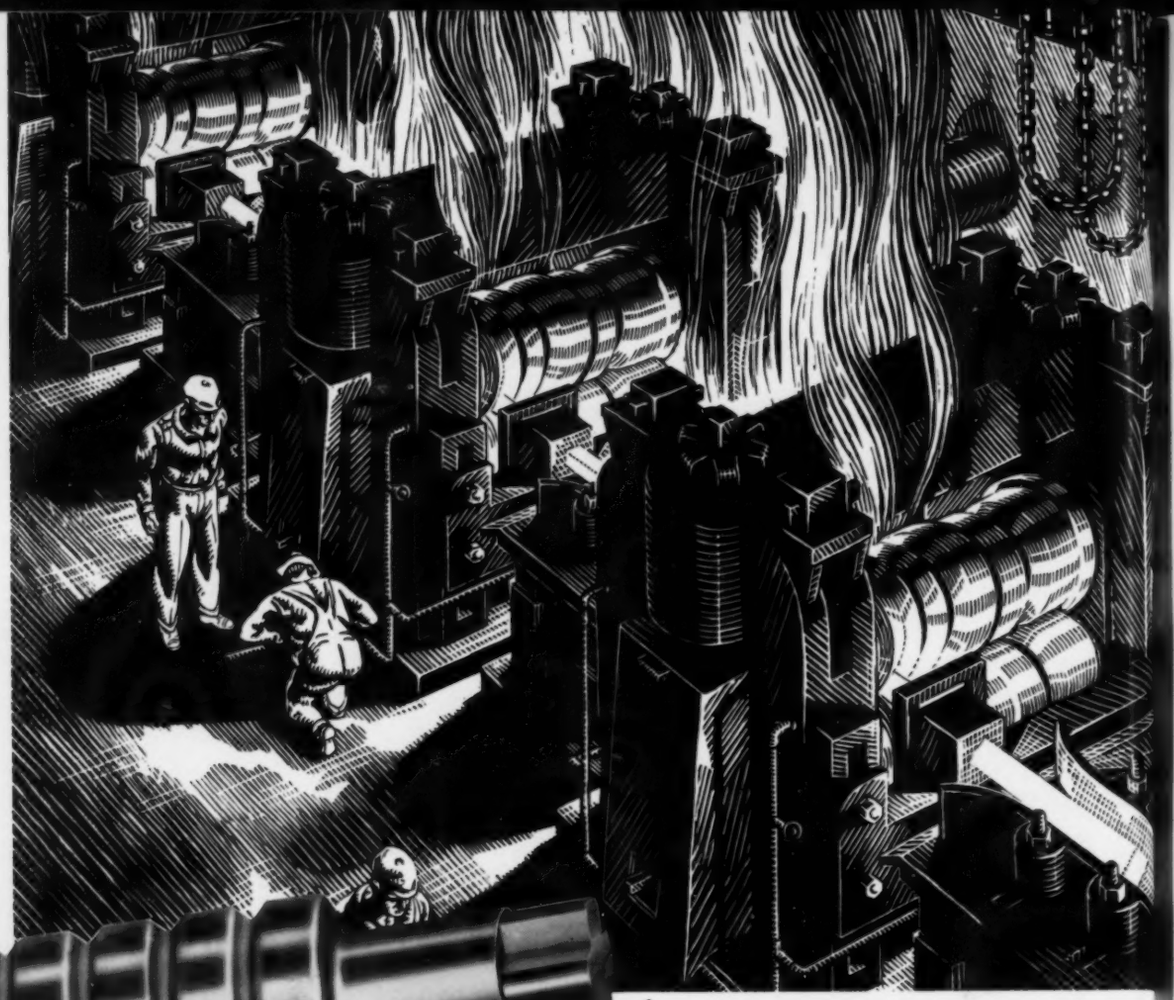
Types MT and OH, used for DC sectionalizing in billet mill.

THE SYMBOL OF QUALITY SWITCHGEAR

I-T-E CIRCUIT BREAKER COMPANY

19TH AND HAMILTON STREETS, PHILADELPHIA 30, PA.

SWITCHGEAR PRODUCTS



Our Rolls are color marked for specific applications

The right roll in the right stand

...assures maximum tonnage per dressing

PITTSBURGH ROLLS

Our roll engineers have the practical experience and know-how to consult with you in selecting the *right* roll for *each* application in your mill . . . a service which is readily available to you.

BLAW-KNOX

BLAW-KNOX COMPANY • ROLLS DIVISION • PITTSBURGH ROLLS DEPARTMENT
PITTSBURGH 1, PENNSYLVANIA

PITTSBURGH ROLLS: Chill • Sand • Moly Chill • Special Rail Finishing • Phoenix "K" • Sandaloy • Pittsburgh 25 • Pittsburgh 35 • Pittsburgh 45 • Pittsburgh 55 • Pittsburgh Special Process • Phoenix 25 • Phoenix 35 • Phoenix 45 • Phoenix 55 • Phoenix Special Process • Phoenixloy • Phoenix Metal • Phoenix Metal Special • Phoenix Metal "F" • Phoenix Metal Master • Carbon Steel • Phoenix "A" • Phoenix "A" Special • Piroco • Piroco "A" • Piroco "B" • Piroco Special • Herculyte

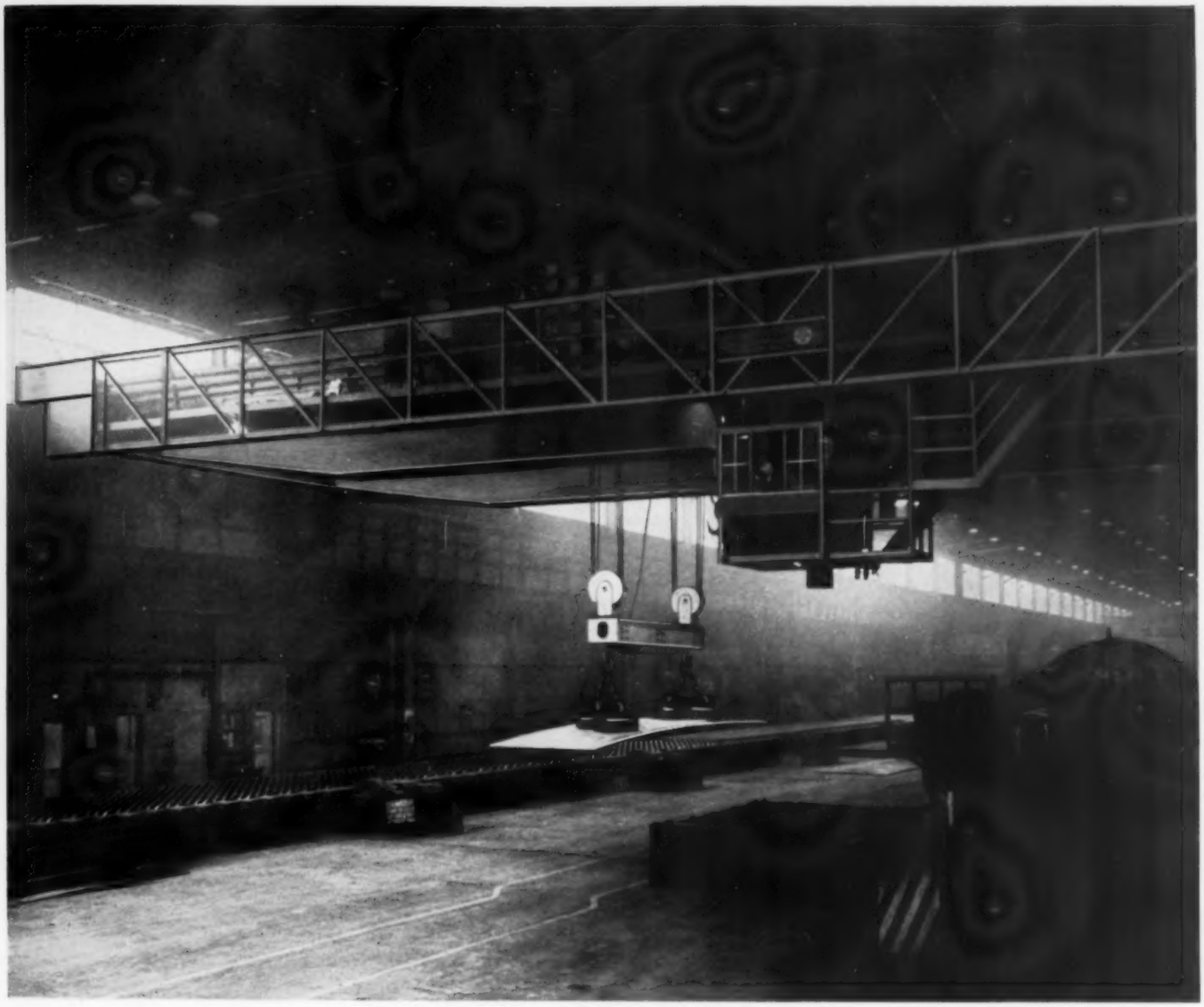


PLATE HANDLING CRANES . . by "Shaw-Box"

You will find many mills handling their plates with "Shaw-Box" Cranes. Plate handling cranes have long been another specialty in the various types of cranes that make up the well-rounded "Shaw-Box" Line of Cranes.

In "Shaw-Box" Plate Handling Cranes — whether built to an individual mill's or to A.I.S.E. specifications — you get the added advantages that come from "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. These added advantages insure crane performance that make "Shaw-Box" Cranes, for the work they do, the least expensive cranes to buy and use.

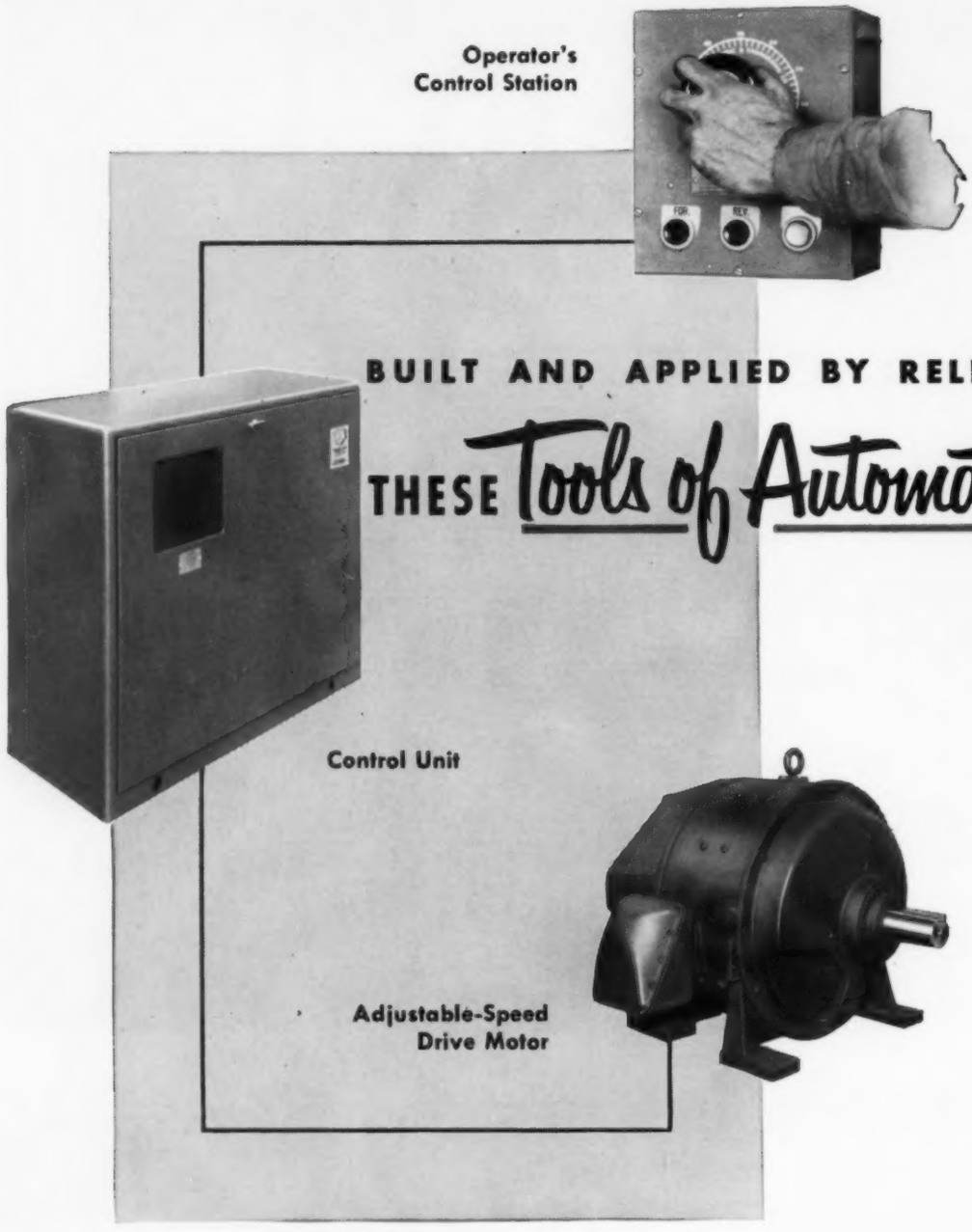
SEND ALL YOUR INQUIRIES FOR STEEL MILL CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX".

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

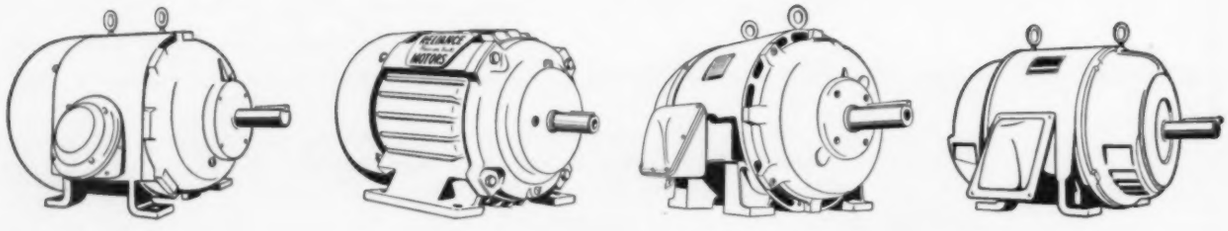
Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' and 'American-Microsen' Industrial Instruments and Aircraft Products.



BUILT AND APPLIED BY RELIANCE

THESE *Tools of Automation* BOOST



RELIANCE ELECTRIC AND ENGINEERING CO.

1084 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*

RELIANCE Precision-Built MOTORS

RELIANCE V★S DRIVE ®

PRODUCTION EFFICIENCY IN EVERY INDUSTRY

. . . From Machine Tools to Processing Lines

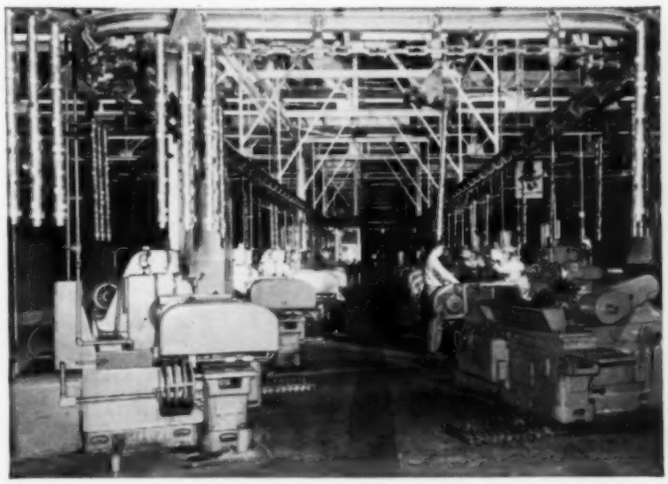
at less cost

If you're looking around for ways to improve your profit ratio—then take a look at these Tools of Automation: They include Reliance motors, adjustable-speed drives, electronic controls, and applied engineering. They've made a lot of companies a lot more competitive.

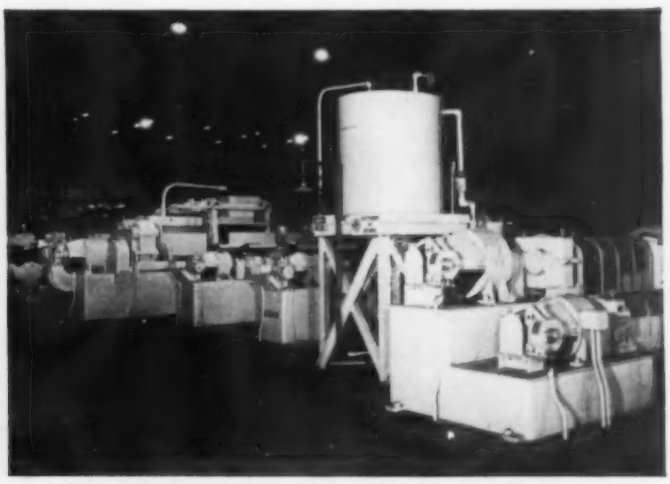
They are used in the world's largest and most completely automated engine plant. And you will find them delivering outstanding performance on machinery in paper, steel, machine tool, textile—in fact, in every industry.

The nearly 50 years of practical, first-hand experience Reliance has in developing, building and applying the Tools of Automation are available to help you automate a single machine... a process... or a complete production line. For all the facts, write for our new booklet, "The Tools of Automation."

A-1485-B



In a camshaft production line, Reliance V★S Drive systems provide stepless, easily adjustable speeds for fast, precision machining. Optimum cutting speeds extend tool life, reduce downtime.



Drive side of the entry end of electrolytic tinning line as viewed from the drag bridle. Reliance Type "T" Heavy Duty Motors provide rugged dependability.

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

IN this issue of the Iron and Steel Engineer will be found the program of the 1954 Convention of the Association of Iron and Steel Engineers, as well as abstracts of the papers to be presented and a list of exhibitors in the Iron and Steel Exposition.

It may sound repetitious to say that these events will be bigger and better than ever, but sure enough, that's true — more technical papers than ever before, more exhibits than ever before, and more interest for the steel man than ever before.

All that remains is for the attendance to be greater than ever before and everybody will be happy. Hope we see you there.

▲

GOVERNMENT loans to foreign countries for industrial plants should not be based only on the soundness of the loan itself, but also upon the economic effect on the United States, in the opinion of E. T. Weir, chairman of National Steel Corp., and other steel leaders.

Mr. Weir's statement was made in connection with a projected $40,000,000 Export-Import Bank loan to National Steel Co. of Brazil for plant expansion at Volta Redonda, but he believes that the principle should apply to any industry and any country.

"Government should not use people's money in any way that will be detrimental to our country," he said.

Mr. Weir also stated that fourth quarter steel business may be somewhat better, but no one can say when the industry will get back to 85-90 per cent operations.

▲

IT'S sort of a sad commentary on American manners that Colonel John R. Dilley, U.S.A., had to issue his edict to army wives in Frankfurt, Germany, barring public wearing of overalls, shorts, bare midriffs and pin curlers, but we're with him. Now, if we could just pass a law over here . . . . !

▲

TWO production figures, said to be industry-wide records, have been set by auxiliary units at United States Steel's Fairless Works. The 80-in. continuous pickling line operated in July at an average rate of 932 tons per eight-hour turn. A four-high sheet temper mill turned out an average of 739 tons per eight-hour turn in July.

▲

BRAZIL, which produced 78,000 tons of pig iron and 74,000 tons of steel in 1937, expects to turn out 1,300,000 tons of iron and 1,400,000 tons of steel in 1954. Expansion programs are under way at Volta Redonda, Monlevade, Acesita, Vitoria and Lafaiete. Plans also call for a new plant to be built by the Vitoria-Laguna Steel Co., to include two 1000-ton blast furnaces and annual capacity for over 1,000,000 tons of ingots.

▲

A balanced economy is when a man knows as many ways to make money as his wife does to spend it.

And they say that money is what we spend for luxuries and owe for necessities.

▲

AND in the same vein, a correspondent says:

The pair who like to bill and coo
And wander through the hills,
Will find that marriage usually
Means fewer coos than bills.

▲

AN equipment manufacturing company has sent out a letter to all its suppliers, pointing out that the return to a standard 40-hour work week with consequent elimination of overtime pay, the ready availability of materials without premium, and the removal of excess profits tax have probably resulted in operating economies that should permit a substantial cut in prices of items which the manufacturer buys from the suppliers. This in turn would enable the manufacturer to reduce his prices, enabling him to sell more equipment and thus buy more products from the suppliers.

Although there have been some price adjustments in various lines and, needless to say, many individual requests by purchasers for price reductions, this is the first general request that we have encountered. It's hard to say how much room there is for this sort of thing, but price reductions should stimulate buying, hold down further wage increases, and brake inflation.

▲

WE don't know much about astrology, but there seems to be something cyclic about mergers. Right now the air is full of them — Bethlehem Steel and Youngstown Sheet and Tube, Packard and Studebaker, Hilton and Statler hotels, to name a few, and to say nothing of other companies linked by rumors.

Another combination of unusual aspects is the pooling of manufacturing operations by Salem Brosius, Inc., and Phillips Corp., with both maintaining their separate corporate identities. It is believed the combination will result in operating economies for both. A long term sales agreement provides that Salem-Brosius will buy Phillips manufacturing equipment with the rate of payment depending on the number of hours the machinery is actually used.

▲

THE vote of Studebaker workers to accept a reduction in wages to help the company weather a rough spot indicates a maturing viewpoint of workers toward the problems of employers. It is encouraging to find this realization that management does not have a bottomless barrel full of money that can be handed out forever. We can only hope that this outlook grows and is accepted by union leaders as well as workers. Many senseless strikes would be avoided, and everyone would benefit.

The "inside" story of *ElectroniK* instruments

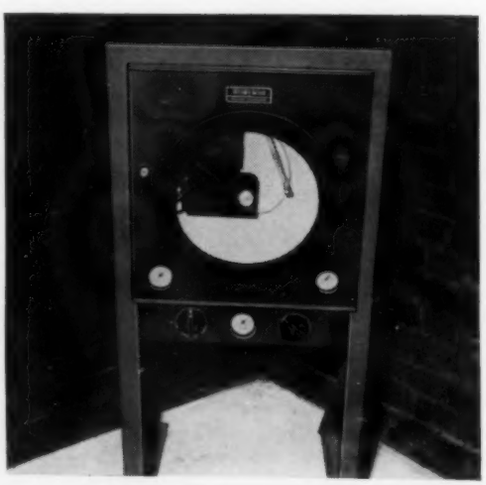
Maybe you've never seen what's inside the case of an *ElectroniK* instrument. And even if you have, you might not realize how each component has been painstakingly refined to contribute its share to the overall performance and dependability of the instrument. Three of these components in particular—the converter, "Continuous Balance" amplifier and the balancing motor—are key members of the *ElectroniK* team with which you should get acquainted.

The Converter is what transforms tiny direct-current signals from the thermocouple or other sensing element into an alternating voltage that the amplifier can conveniently handle. In principle, it is somewhat like the vibrator in your automobile radio. But because it deals with such small bits of electrical energy, it has been designed of carefully selected materials which prevent the introduction of misleading signals into the measuring system. It is hermetically sealed against the effects of dust, humidity and atmospheric pressure change, and is shielded against stray electrical and magnetic fields.

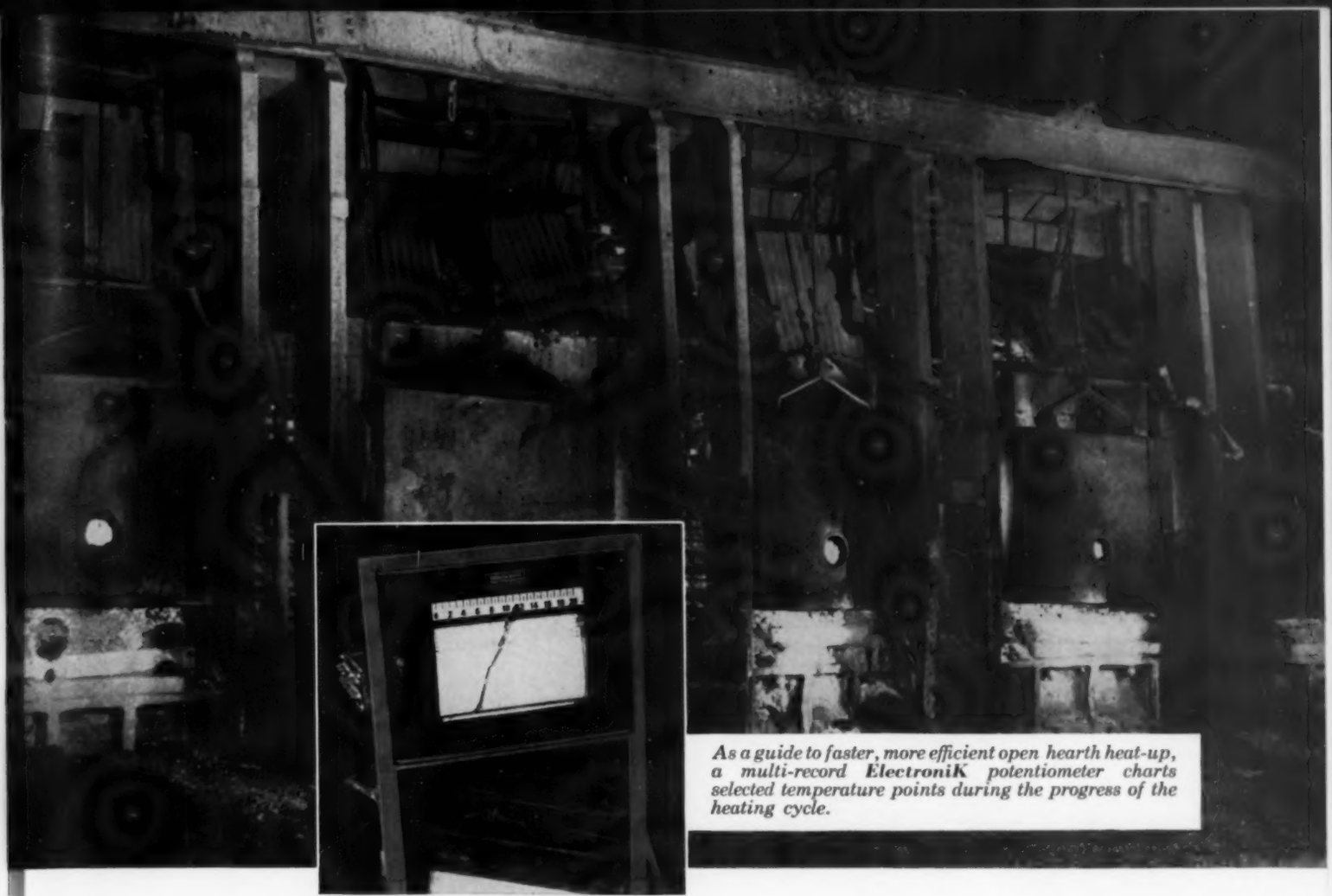
The "Continuous Balance Amplifier" boosts the incoming signals by millions of times . . . makes them strong enough to operate the balancing motor. Although it looks like part of a radio chassis, few communications circuits could equal it for quality. It uses standard, easily obtained parts, which are operated far below their normal ratings to insure exceptionally long life. The circuit has great stability against drift and pick-up, and is thoroughly temperature compensated.

The Balancing Motor does the work of moving the pointer, recording pen and any control devices that may be incorporated in the instrument. It packs plenty of power into a small space . . . gives ample torque to give fast, accurate positioning whenever the amplifier calls on it. Totally enclosed, the motor is impervious to dust, dirt and changes in mounting position.

Open hearth heat-ups speeded ...costs reduced...



For a fully automatic heat-up, a circular chart program controller regulates fuel input to bring the furnace to temperature along a specified time-temperature curve.



As a guide to faster, more efficient open hearth heat-up, a multi-record ***ElectroniK*** *potentiometer charts selected temperature points during the progress of the heating cycle.*

with ElectroniK instruments

WHENEVER an open hearth furnace is being brought back in production after repairs, the time and expense of heat-up can be substantially reduced with the help of *ElectroniK* instrumentation. In place of the old "rule of thumb" methods so widely practiced in heat-ups, these instruments provide operators with accurate data on which to base fuel adjustments. When desired, the instruments can automatically bring the furnace to temperature at a preset schedule . . . without attention by operators.

The thorough, even heating that is made possible adds substantially to the life of refractories. At the same time, rate of heating can be held at the fastest safe rate, and total time and fuel consumption during heat-up can be kept to a minimum.

Two alternate instrument systems are available. Where manual regulation is preferred, an *ElectroniK* four-record strip chart instrument records temperatures of thermocouples in the furnace at selected locations above doors and in the roof. A special chart makes it easy to compare the heating curves with the desired time-temperature relationship, to facilitate manual adjustment of fuel. For fully automatic control, an *ElectroniK* circular chart program controller regulates fuel input to make temperature rise evenly at a prescribed number of degrees per hour. Instruments are usually mounted in a simple steel frame, to make the control system movable for transfer from furnace to furnace as needed.

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MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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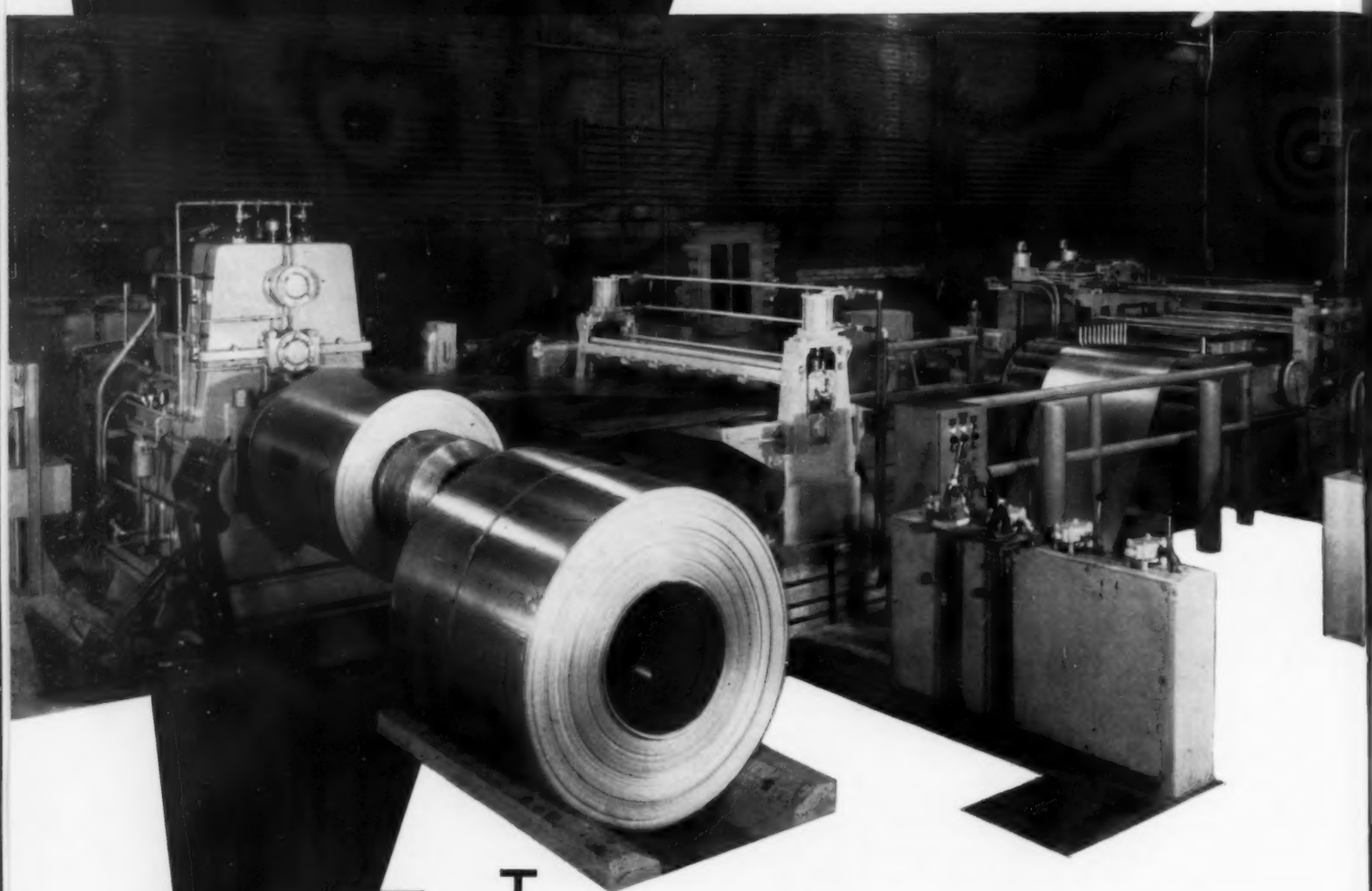

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MOORE RAPID

WHEN YOU MELT... *Lectromelt*

ULTRASONICS in Maintenance Planning and Product Quality Control

By R. L. RECTENWALD
Maintenance Engineering Corp.
Pittsburgh, Pa.

. . . . early detection of incipient failures by ultrasonic means can eliminate many maintenance headaches . . . .

▲ ONE of the more promising developments stimulated by military research during the past ten years has been the conversion of sonic energy to industrial utility of economic value. The phase of sonic energy which is the subject of this discussion is the application of high frequency vibrations as a tool for maintenance inspection of industrial equipment and for inspection of products as a means of quality control. Several commercial instruments using the ultra-sonic principle have been developed to facilitate measurement of metals, for flaw detection, for corrosion surveys, and for quality control measurements on the production line. Unfortunately, we know of no single instrument which will adequately fulfill all of the industrial needs for thickness measurements, and flaw detection. This discussion will therefore be limited to two types of ultra-sonic instruments which operate on slightly different principles and cover most industrial inspection application with some overlapping of their respective fields.

The two instruments considered in this discussion are classified under the general heading of ultrasonic instruments because they operate above the audible frequency range. The human ear is sensitive to sonic vibrations in the frequency range of about 50 to 20,000 cps and this range is commonly termed the audiosonic range. By comparison, the ultrasonic frequency range used for thickness measurements and flaw detection is usually between 0.5 Mc and 10.00 Mc (One megacycle Mc is equal to one million cycles per second).

TRANSDUCER OR SEARCHING UNIT

Both of the systems use similar means for converting electrical energy to sonic energy. The device which converts the electrical impulses to sonic or mechanical impulses is known as a transducer. In the case of these inspection instruments, the transducer is properly termed a "piezoelectric transducer" and is often referred to as the crystal, probe or searching unit (Figure 1). The transducers are made from certain mineral crystals, such as quartz, rochelle salts or barium titanate, a ceramic material, and are mounted in a suitable holder with electrical connections. These transducers will vibrate when subjected to rapidly reversing electrical impulses, and likewise when the transducer is vibrated mechanically it will convert the mechanical energy into electrical impulses. The thickness of the transducer determines its natural frequency which determines the most efficient range of operation and sensitivity for inspection work. The design and manu-

Figure 1 — Transducers come in a variety of sizes and shapes to suit the surface of the material being checked.

facture of efficient transducer crystals in a wide variety of sizes and shapes is a highly skilled art which relatively few individuals or companies have mastered. The production of transducer crystals is practically on a laboratory scale and are not manufactured on a mass production basis.

SURFACE CONDITIONS AND COUPLANTS

All of the ultrasonic methods depend upon intimate contact with the work or at least reasonable indirect contact through an intermediate medium such as oil, glycerine or some special greases. These substances are called couplants because they provide the means of coupling the quartz face to the material in such a manner that the sound waves will be transmitted across the interface gap with maximum efficiency. The coupling materials must be liquid or of medium grease consistency in order to conform to the irregularities and curvatures of the inspected surface. The couplants are uncompressible media as compared with air or gases, and at high frequencies transmit the pulses from and to the transducers in the same manner that the liquid in a hydraulic cylinder transmits compressive loads.

Although the couplants simulate contact between transducer and work, any departure from parallel relationship of these interfaces has the effect of reducing the amount of sonic energy transmitted in a directon perpendicular to the quartz face. Severe variations in the surface opposite the transducer or fractures at oblique angles present some difficulty in obtaining accurate readings. As a rule the experienced operator can obtain fair results even under adverse field conditions so that the general condition can be determined even if precise readings are not obtainable. Special curved crystals are made for measuring spherical surfaces, for outside cylindrical surfaces under about eight inches outside diameter and for practically all concave surfaces where the radius is under about five feet.

THE BASIC SYSTEMS

The ultrasonic inspection methods depend upon two fundamental characteristics of sound waves. Sound travels through materials at a velocity that is a function of density and of elastic constants. The velocity is not greatly influenced by wide variations in temperature and is essentially independent of chemical composition, heat treatment, internal stress or magnetic properties. The second characteristic of sound which makes ultrasonic testing possible is the phenomenon by which sound waves are reflected by the interfaces separating two materials such as metal and air, water, glass or coatings which have different accoustical impedances. Some of the hard to measure metals are porous bronze castings, grey cast iron, lead, sintered metals, etc.

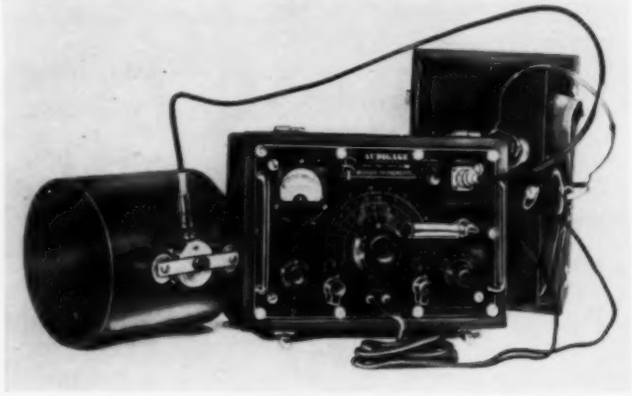
The inspection instruments, operating on the fundamental principles of transmitting and measuring the speed of sound through a given medium have some properties and limitations which are common to all. Because of differences in the two principal measuring systems there are definite fields of application where an instrument of one system is more suitable than one of the other. The two systems of measurement are known as "resonance systems" and "reflection or echo systems."

Resonance systems—The resonance system is based on the principle that a given material will have a definite frequency of sonic resonance which is proportional to its thickness. Standing waves can be set up within a metal plate or pipe wall, just as standing waves are set up within the air column of an organ pipe. The frequency of the standing waves depend upon the thickness of the material and the velocity of sound in the material, just as the frequency of the organ pipe depends upon the length of the air column and velocity of sound in air. The material is said to be in sonic resonance when an impulse from the energized transducer travels from the measuring surface through the material at constant velocity, and is reflected back to the measuring surface at the precise instant that the succeeding impulse is emitted from the transducer. Since the velocity through a given material is constant, the time required for the impulse to traverse the round trip is a function of the distance traversed or twice the thickness in this case. The time interval between successive impulses or cycles at resonance is therefore directly proportional to the thickness. It follows that if the rate of oscillation of the electrical impulses can be adjusted to produce the resonance condition in materials of various thicknesses, the thickness measurements can be determined by measuring the frequencies at which resonance occurs. Resonance conditions also occur at multiples of the fundamental frequencies which are known as harmonics.

There are several thickness measuring instruments using the resonance system and the one we have selected for discussion (Figure 2) is completely portable and battery operated so that it can be used at any field location where a man can find access. This basic instrument weighs about 18 pounds, occupies a space of about one-half cubic foot and is carried from a light shoulder harness. The thickness measuring range of the two basic instruments, covering a frequency range of 0.65 to 6 Mc, is 0.020 to 12-in.

A permanent magnet holding device (Figure 3) clamps the crystal in position against the measuring surface so that the operator has both hands free for operating the instrument and tabulating thickness data. The cost of this unit is slightly under $1000.

Figure 2 — The operating panel of resonance unit shows milliameter and frequency scale of 0.65 to 2-Mc as well as circular slide rule for computing thickness.



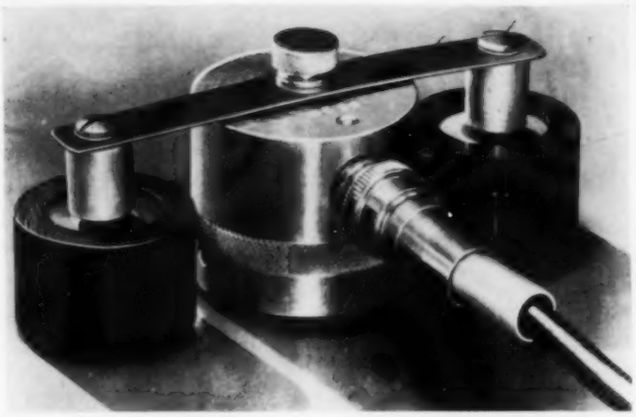


Figure 3 — A permanent magnet holding fixture is here used with a right angle searching unit.

The gage has the unique feature that it detects the resonance condition by producing an audible signal or squeal in radio type head phones worn by the operator. A milliameter has also been incorporated as a visual aid in addition to the audible signal to facilitate accurate location of the resonance points. The operator varies the frequency by a sweep of the dial calibrated in frequency and reads the frequencies at which sudden high pitch sounds are detected. These points indicate the fundamental frequencies or successive harmonics which are exact multiples of the fundamental frequency. The fundamental is either read direct or obtained by differences between any two succeeding harmonics. The thickness in mils is read directly from a circular slide rule scale on the instrument. Figure 2 shows the operating panel of the gage.

Figure 4 — A resonance unit is here shown checking the thickness of a storage tank.

ACCURACY AND CHARACTERISTICS OF RESONANCE SYSTEM

When both surfaces of the material are parallel to the transducer and clean, the audible signals are sharp and well defined so that the resonance frequencies can be read accurately. Under such ideal conditions as would be found on new steel plate or pipe, the measurements can be read within one per cent accuracy. If the material is severly pitted or tapering so that the thickness variation directly under the transducer is in the order of 20 per cent of wall thickness, the audible signals are very broad and accurate measurements may be difficult. In severe cases a constant hum would be heard over the entire scale and it may be impossible to detect any harmonics. Under this condition the operator would recognize the severe corrosion but would be unable to make accurate measurements.

The majority of maintenance inspection applications fall between the two extremes described and a very small percentage would fall in the impossible range. Where the harmonics can be recognized with difficulty the accuracy will usually be within five per cent. From the above, it can be appreciated that the operator should be thoroughly familiar with the instrument and under the supervision of a person with some technical training and a general knowledge of the conditions he will encounter in field testing.

APPLICATIONS FOR RESONANCE SYSTEM

For general purposes maintenance testing the standard gage having a frequency range of 0.65 to 2.0 Mc and thickness range of $\frac{1}{16}$ to 12-in. would be used. On very

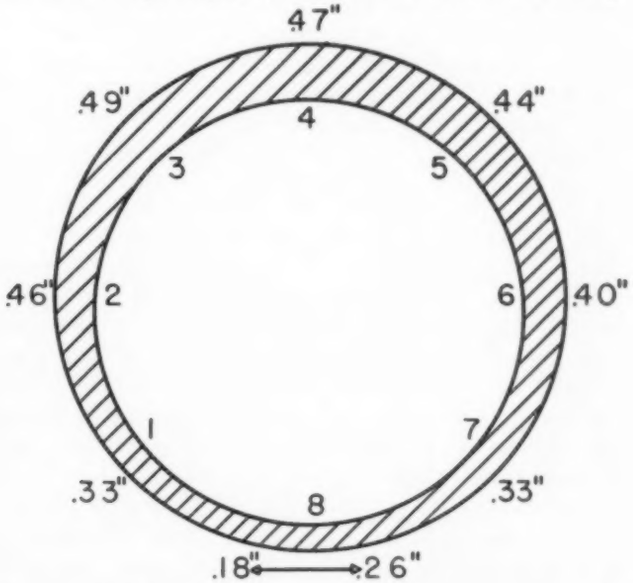


Figure 5 — Plot shows pipe thickness measurements on a 5-in. outside diameter steel tube. Loss of metal due to corrosion is illustrated.

thin materials and some new product inspection, the 2-6 Mc instrument is often better. While the standard instrument is usually suitable for routine testing of new products, the accuracy can be sometimes improved and the operation simplified by designing direct reading scales to read between close limits for certain applications.

There are numerous applications in industrial plants

Figure 6 — Gage can also be used to check thicknesses under water. A diver is here using the probe unit.

Figure 7 — Supplementing the diver in Figure 6, an operator above the waterlevel records the data measured by the diver.

for thickness measurements which can be used as a guide for long range maintenance planning. An intelligent inspection program would permit major replacements and repairs of deteriorating equipment to be made on schedule outages rather than to operate blindly until a gas line ruptures, structures collapse, or other catastrophe occurs with possible personnel casualties and prolonged curtailment of production. A few of the typical mantenance applications which are scheduled for routine inspection on some plants are: boiler drums and tubes, ceramic lined steel stacks and blast furnace shells, raw gas lines, coke by-product plant equipment, coal chutes and storage bins, pressure vessels, barge hulls while afloat, acid tanks, raw water lines, structural steel, box type crane girders, crane rails, pulverizer and crusher shells, and in general all equipment subject to corrosion or errosion or flaws in normal operation. See Figure 4.

Figure 5 shows a typical inspection of an eroded refinery tube and the variation in wall thickness as measured by the gage. The gage measurements were all within 2 per cent of micrometer measurements and the testing conditions are about average for field testing.

Figures 6 and 7 show an unusual under water application of measuring thickness of sheet piling and river locks. Ultrasonic thickness measurements are accepted by boiler and marine inspectors and underwriters instead of the old method of drilling and plugging test holes or less desirable hammer testing.

Under the heading of new product inspection, some of the applications are: lamination of tubes and plate, eccentricity of tubes, thickness of dished heads or other deep drawn products, thickness of tube bends or forged fittings, thickness of coiled strip, checking bond of clad metals and inspection of new fabricated equipment. Inspections of the type mentioned are suited to the gage because the portability and battery operation make it more convenient than some of the a-c operated instruments. In other types of new product inspection where the instrument is mounted in a fixed position and thickness variation is held within close limits, the direct reading instruments facilitate more rapid inspection. The ultrasonic micrometer was recently developed with a direct reading scale and calibrated to measure thickness within a given range to an accuracy of 0.0001-in.

The most recent development in quality control inspection instruments late in 1953, was one which is a direct reading instrument by which thickness measurements may be read directly on a 21-in. cathode-ray screen (Figure 8). Measurements can be read in graduations of 0.0001-in. in a thickness range of 0.015-in. to 6-in. of steel with accuracy as low as 0.1 per cent, depending upon the application. The gage operates on 100-115v, 60-cycle, a-c and may be used with a 100-ft probe cable if desired. This instrument is particularly suited to high speed high-accuracy inspection of new materials such as seamless tubes, sheet materials, extrusions, deep drawn and large spun parts of practically all metals, glass plastic and other homogeneous solids. At the present time, there is no other instrument which approaches the versatility and accuracy of this gage for new product inspection for thickness or laminar flaws.

The resonance instruments will detect flaws within

Figure 8 — One gage design gives visual indications directly by insertion of a calibration screen over the cathode-ray screen. Most materials can be measured with an accuracy within 0.0001 in.

Figure 9 — Flaws in railroad rails are indicated by a change in a signal pitch.

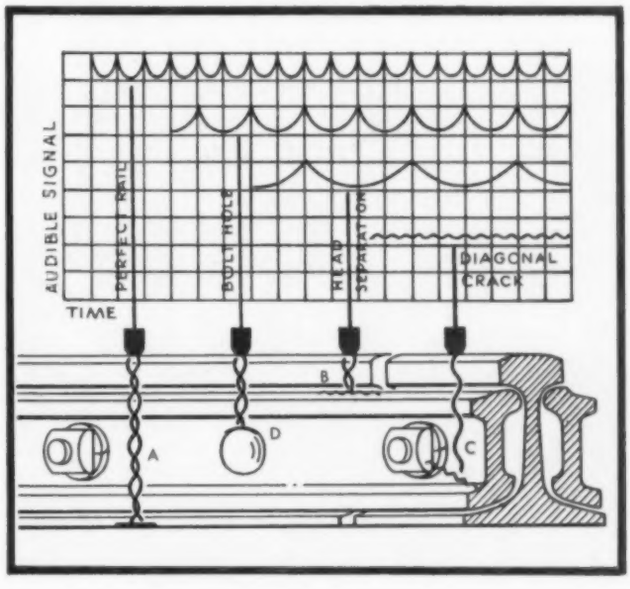
their range of penetration, (i.e., up to 12-in. deep in steel) by indicating the thickness between the measuring surface and the discontinuity. A special flaw detector, developed for detecting flaws in rails or other members of uniform cross section is shown in Figure 9. The instrument is tuned to the sound section and the transducer is moved along the rail until a sharp change in tone is detected, which is the indication of a flaw, bolt hole or other change in section. Crane rails and coke oven rail inspections are critical items in the steel industry. This instrument is adaptable to routine testing of bars or new products which are uniform in cross section. Figure 10 shows a graphic indication of the types of signals produced for various discontinuities or flaws in rails.

THE REFLECTION OR ECHO SYSTEM

The reflection system of inspection differs from the resonance system in principle and in application. There is only one instrument of this type on the market. This is a fixed frequency instrument with a pulsing signal as compared with the resonance gage previously described which emits a steady signal of any frequency within the range of modulation of the oscillator circuit. The signals of sonic energy are emitted from the transducer in pulses of a few microseconds duration at the rate of 60 pulses per second. The frequency of the short pulses is set on the instrument at ½ Mc, 1 Mc, 2¼ Mc or 5 Mc depending upon the type of material to be inspected and sensitivity required. A transducer is selected to match the test frequency desired. In this system, the short pulse at a selected frequency is emitted from the transducer into the material and is reflected from the opposite side or from an intermediate discontinuity and transmitted back against the quartz face before the succeeding signal is emitted. The transducer receives the reflected impulse and transforms the mechanical vibration into a small electrical impulse which is amplified by electronic circuits and projected on the screen of a cathode-ray tube as "pips" or narrow blurs.

The relative distance between the "pips" on the screen is measured by the waves in a scanning line which is projected across the horizontal axis and is

Figure 10 — Changes in pitch due to discontinuities and defects in the rail are shown by this chart.



adjustable to represent distances up to 30 feet in the screen.

The unit is housed in a metal case which has a volume of about 3½ cu ft and weighs approximately 130 pounds. The instrument operates on 115 volt, 60-cycle, single-phase, a-c and may be operated satisfactorily in the field by a reliable gasoline powered generator of 250-watt capacity. The size and weight of this instrument make it cumbersome to operate in some field locations where space or lack of scaffolds does not afford convenient manipulation. Since the standard instrument is designed to operate with a six-ft searching cable the operator must have the instrument within that distance of the work. In many applications it has been found desirable to provide searching cables up to 30-ft in length in order to facilitate inspection of crankshafts on presses and other equipment which cannot be reached from the floor. The use of the special long cables requires some tuning adjustments and probably reduces sensitivity slightly; but, the increased utility is usually justified for this work. The unit with standard accessories sells for approximately $4500.

The efficient and practical thickness range for this gage is from about one inch to 20-ft in steel. At the lower limit it becomes difficult to read the closely spaced "pips" on the screen, and at the upper limit the sonic energy is absorbed or dissipated so that a point is reached where the reflected signal does not reach the transducer. The point of diminishing efficiency in thickness measurements for the reflection system becomes the point of maximum efficiency for the resonance system, which makes the two systems complementary and compatible for a wide range of industrial inspections.

APPLICATIONS FOR THE ECHO SYSTEM

In the field of maintenance inspection, the most intelligent and profitable application is to establish a routine inspection program of all critical equipment as a part of preventive maintenance program. All machine elements subject to high stresses with frequent reversals are a source of fatigue failure and should be inspected at regular intervals. Crankshafts on forming presses, turbine rotors, built up crankshafts on large engines and marine equipment, piston rods, mill spindles, rolls and roll necks, pinions and gears, steel ladle trunions, forging hammer rams and sow blocks are but a few of the items which fail regularly in many plants. Many of these parts can be inspected from an exposed end or surface with little or no disassembly. The discovery of a flaw or progressing fracture will often forestall a serious accident and curtailment of production. By detecting these conditions early, replacement parts can be obtained or repairs planned for scheduled outages. Equipment can often be operated with comparative safety by frequent inspection of the defective part in order to check the rate of propagation of a fracture or to determine other changes which could be used as a guide in establishing working loads or production schedules. The presence of an incipient fracture or internal flaw does not always mean cessation of operation and scrapping of costly equipment because very often some of these defects can be tolerated where the location is not in a critical area and very often repairs can be made to correct the condition.

BLOOMING MILL ENGINE SHAFTS

The nature of many heavy metal forming operations frequently subjects equipment to overloads never anticipated in the original designs. Because of this overload hazard, designers sometimes favor the frame and other major structures by designing the crankshafts as the weakest link in the chain of machine elements performing the heavy metal forming work. In some heavy mill engines, forming presses and upsetters, the crankshafts are almost considered expendable elements because of the high frequency of replacements. Where such failures are expected from time to time, a rigid inspection program is often established in order to detect the first indication of fatigue failure. Early detection of these failures allows time for rescheduling of production ordering replacement parts and very frequently repairs can be made which will forestall complete failure. Tremendous savings in production

Figure 11 — This 44-in. blooming mill engine crankshaft was checked by a reflection type ultrasonic unit.

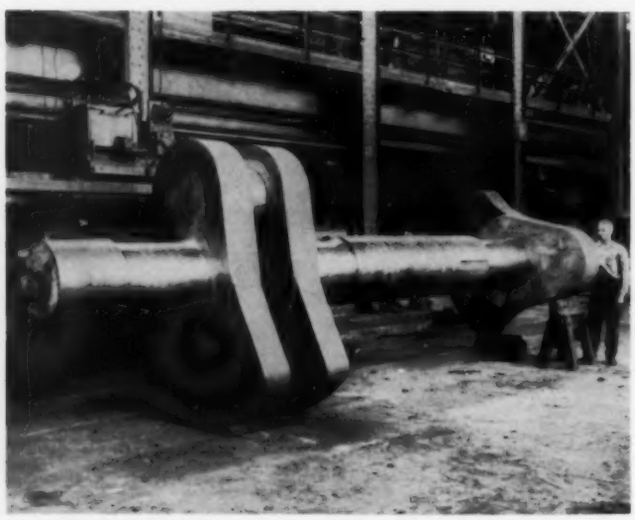
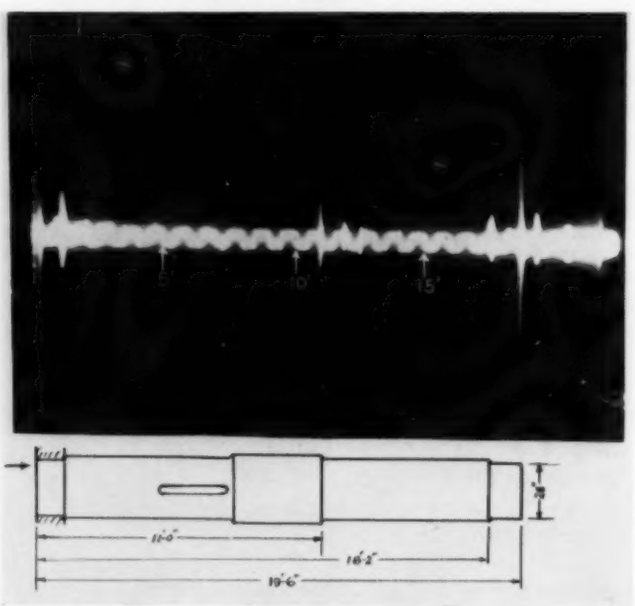


Figure 12 — Photograph shows reflections in main shaft of 44-in. blooming mill engine.



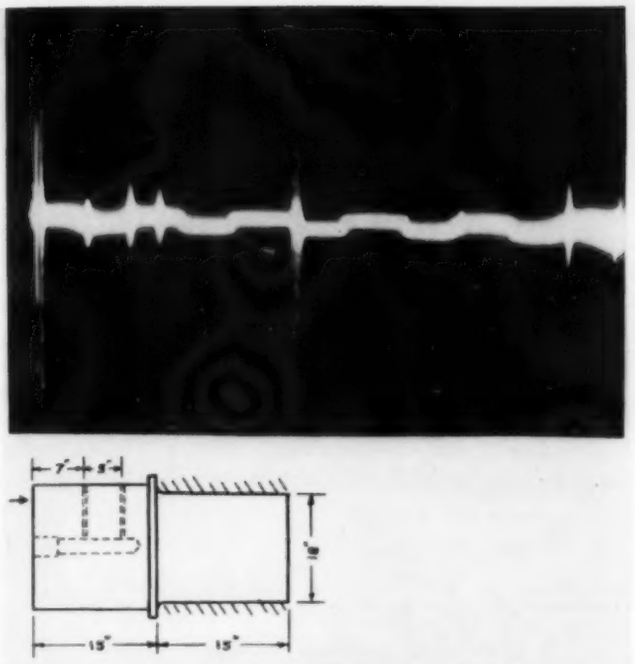


Figure 13 — Photograph shows reflections in single crank pin of 44-in. blooming mill engine.

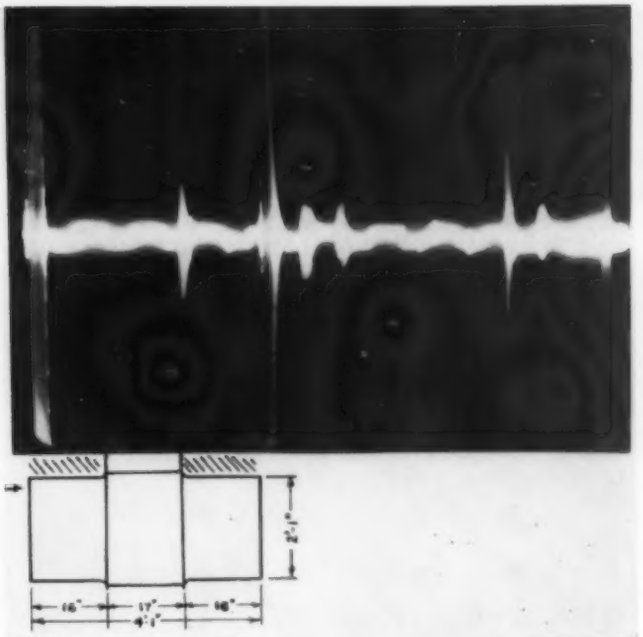


Figure 14 — Photograph shows reflection of marine crank pin of 44-in. blooming mill engine.

time can be realized by the orderly maintenance planning provided by ultrasonic testing.

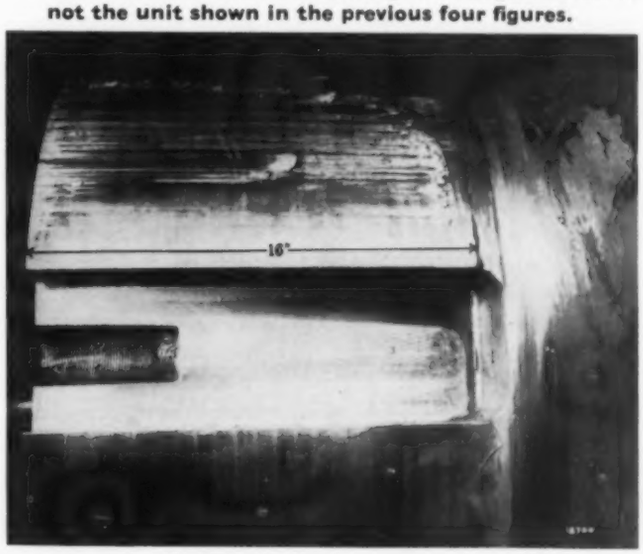
The high rate of steel production in several mills during the past two years can be attributed in part to the early detection of fractures in blooming mill engine crankshafts. The ultrasonic tests in most cases were the only possible means of detecting fractures in the interference fits which were inaccessible for any surface inspection. In all cases the inspections were relied upon as a guide for planning production schedules, for immediate temporary repairs and for evaluating the condition of all components of the shaft before replacing a defective crank pin. A typical inspection story is told by the series of photographs and reflectograms (Figures 11 to 14) showing a 125-ton crankshaft from an engine of about 25,000-hp. The ends of the main shaft sections, crank pins and coupling end can be made accessible for inspection in the engine in a few hours. The series of reflectograms in this instance are from a shaft having no gross defects. In all cases the back reflections from the opposite end of the shaft elements show clearly with the approximate reflections from shoulders, oil holes and fillets. The reflectogram in Figure 14 of the marine crank pin shows a slight reflection about two inches from the end reflection which could be a minor defect in a non-critical area. The strong back reflection from the end rules out the possibility of a gross fracture. A fractured single crank pin is shown in Figure 15 after it was discovered in service and replaced when the shaft was rebuilt.

PRESS INSPECTIONS

Detailed drawings are essential for good results where parts to be inspected are assembled in equipment. Such details as keyways, oil holes, undercuts and shoulders may be interpreted as flaws if their location is not accurately determined prior to inspection. A routine inspection of all forming press crankshafts in one manufacturing plant recently provided a typical case which demonstrates the application, limitations and advantage of ultrasonic inspection. In one eight-hour day, ten crankshafts were inspected in place. These shafts were all of single throw design with pin sizes ranging from 8-in. to 33-in. diameter. The only exposed surfaces of these shafts were the two ends and the sides of the crank arms. From these exposed surfaces, it was possible to check all critical areas where fatigue failure was known to occur, namely, the center of the fillets at locations A, B, C and D in Figure 16.

The result of the day's inspection revealed two fractured shafts of the ten inspected. One of these fractures was just starting in the pin fillet at location "B" and had progressed less than 10 per cent through the cross section. It was decided that this shaft could be repaired effectively in place at less than 5 per cent of replacement cost. The outage time for repair would be about 2 to 3 days. Delivery on a new crankshaft at that time was six months.

Figure 15 — Photograph shows defect found in a single crank pin of another blooming mill engine. This is not the unit shown in the previous four figures.



The second fractured shaft weighed 17 tons, was about 15½ feet in length with a pin diameter of 3-in. The general inspection revealed a fracture starting in the crank pin fillet at location "C" extending over 75 per cent through the cross section of the arm. A detailed inspection accurately located the internal path of the fracture and confirmed the original observation that the fracture did not progress to the main journal fillet. Due to the critical need for the production of this press and some favorable experience with extensive repairs on similar shafts, the management decided to repair in place the fracture which totaled over 5 feet on the surface. The decision to repair this shaft was justified in the hope that press could be operated another six months until a new shaft could be procured. The cost of the repair was estimated to be about 20 per cent of the cost of a new shaft.

Under these circumstances more frequent routine inspections would be recommended in order to catch fractures in the early stage of propogation. In addition to assuring production, many safety hazards are eliminated such as fractures adjacent to flywheels and bull gears on overhanging shaft extensions.

NEW PRODUCT INSPECTION BY REFLECTION

In new product inspection, the gage is without peer for inspection of large forgings, steel castings, tool steels, die blocks, billets and other rough stock from which expensive machined parts are to be made. Thousands of dollars in machining cost and production time can be saved by discovering objectionable defects in the rough stock. A hidden defect in a turbine rotor could cause total loss of an entire unit costing hundreds of thousands of dollars, whereas, detection of the flaw in the rough forging would reduce the loss to a small fraction of the cost of a failure in service. Figure 17 shows a large hydraulic casting being inspected before completing machining operations. The technique of immersed testing of irregular shapes and small parts has been developed recently as a production test method, and is being widely adopted in the aircraft and aluminum industries. The parts are immersed in water as a couplant and direct contact with the quartz face is not necessary.

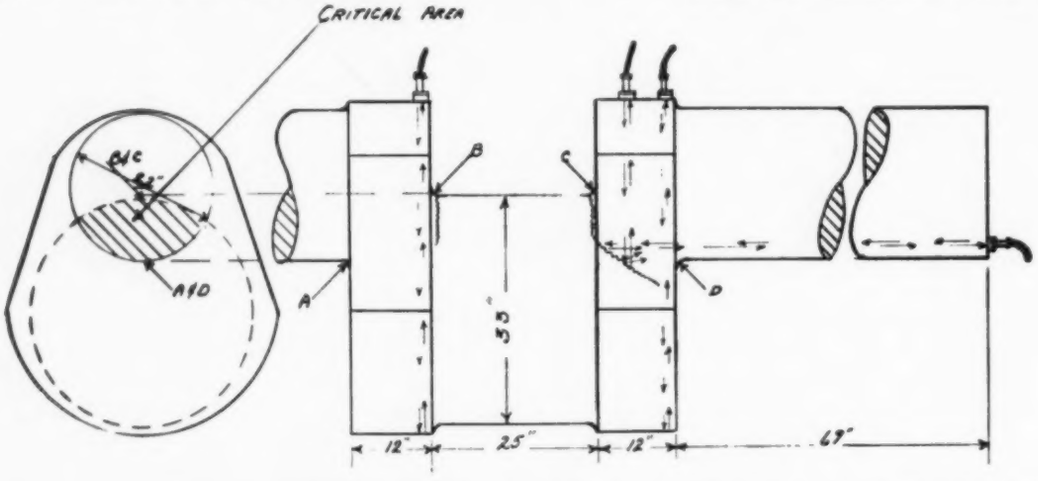


Figure 16 — Diagram shows likely areas for failures in a 15-ton forming press crankshaft.

After the pitman arm and crank pin bearing were removed, further tests were made with penetrants and magnetic particle methods to confirm the ultrasonic test. At this time a new fracture was found in the opposite pin fillet which was 21 in. in length and extended about 10 per cent through the cross section. See location B of Figure 16. This fracture was parallel to the inner face of the crank arm and had progressed slightly below the fillet. While the reflecting gage did indicate the inner face of the crank arm and would indicate the fracture which was in the same plane, it would be difficult for the operator to distinguish the shallow fracture from the crank arm face. The end of the shaft from which the inspection of this area was made was 81-in. from the fracture and at that distance, the diverging angularity of the searching beam would account for some lack of sensitivity. It would also be necessary to accurately lay out the pin projection on the end of the shaft in order to detect shallow fractures in the fillet area. Since it is sometimes very difficult to obtain accurate dimensions of assembled parts, detail drawings should be obtained whenever possible.

This survey illustrates how an inspection program will predict failures which would otherwise result in prolonged production curtailment if allowed to progress. The inspection located two gross fractures in time to take corrective measures and extend normal production time. One fracture was overlooked because detailed drawings were not availabe and field conditions precluded accurate measurements.

Figure 17 — Large hydraulic casting is being checked before additional money is invested in the machine.

ANGLE TESTING SURFACE INSPECTIONS

The reflecting gage is adapted to testing of tubular sections and pipe by use of a special angle crystal mount which directs the waves into the material at about 45 degrees to the surface. The waves bounce alternately from the opposite surface to the measuring surface until they return to the crystal from the opposite side of the tube from which they entered. This method is coming into general use in the inspection of pipe and weldments.

A very recent development was the design of a searching unit to detect surface defects such as seams, laps, segregations and incipient fractures on or near the surface. The surface searching unit has a range of about 10 feet and operates very efficiently on smooth surfaces. The surface fracture or flaw is indicated on the screen in the same manner that the internal flaws are indicated.

THE INSPECTION PROGRAM

These two instruments are complementary because of their overlapping thickness ranges and the characteristics which enable them to cover a wide range of thin wall measurements of corroded materials, deep penetration for flaw detection and surface inspections. The incorporation of these instruments in a maintenance planning program would permit better scheduling of major replacements and repairs. It would provide the opportunity to order replacements in advance of scheduled outages and reduce the possibility of forced outages and accidents which frequently result in property damage, loss of production and personnel casualties. Use of the ultrasonic instruments in a routine inspection program also permits safer operation under controlled conditions when it is necessary to favor equipment with lighter loads and pressures where known minor defects or corrosive conditions exist. After an inspection program has been in operation for a few years, the frequency of inspections will be adjusted through experience. Some equipment which is particularly critical in production, or where there is a design weakness, or is subject to severe operating conditions, may require weekly inspections. Less critical equipment such as building steel and service piping may require little or no inspection. Some large organizations have established central inspection departments to handle all phases of plant or company inspection work.

COMMERCIAL TESTING SERVICE

Most of the manufacturers of the testing equipment also provide an inspection service on a fee basis where the work would not justify purchase of equipment and training of personnel. There are also several companies specializing in commercial inspection work of all types where several types of inspection instruments and methods are employed. The general inspection service is often more conclusive because measurements and observations can be confirmed by several methods. The preceeding discussion indicates that no single instrument or method is suitable for all applications and it is often desirable to confirm surface fractures by magnetic particle methods, penetrant method, or by microscope.

The commercial testing organizations or company inspection departments have trained personnel who are familiar with the limitations of the various methods and usually are acquainted with the typical locations where failures are likely to occur. The experienced inspection engineer can often obtain consistently accurate measurements on difficult jobs where the inexperienced operator would have difficulty in interpreting indications. By utilizing these nondestructive testing facilities and correlating test data with field experience in observing equipment failures, an accurate diagnosis of the cause of failure is provided. With such complete data on defective equipment available, economic plant operation strongly favors increased use of ultrasonic testing as an important manufacturing aid.

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DISCUSSION

PRESENTED BY

S. M. MATTHEW, Engineer, Maintenance Committee, United States Steel Corp., Munhall, Pa.

R. L. RECTENWALD, Maintenance Engineering Corp., Pittsburgh, Pa.

W. A. BLACK, Engineer, Steel and Tubes Div., Republic Steel Corp., Cleveland, Ohio

SAMUEL B. WEST, JR., Mechanical Engineer, Maintenance Dept., Hoover Co., North Canton, Ohio

GEORGE FRENCH, Master Mechanic, Blast Furnace, Bethlehem Steel Co., Bethlehem, Pa.

RALPH H. FRANK, Sales Engineer, Sperry Products, Inc., Danbury, Conn.

JOSEPH A. MARLAND, Vice President, W. A. Jones Foundry and Machine Co., Chicago, Ill.

S. M. Matthew: This paper highlights the theory, application and use of ultrasonics in detecting flaws in metals, and should serve as a valuable guide to mill maintenance personnel and those concerned with product quality control.

We have recently developed a preventive maintenance program in Central Operations of the U. S. Steel Corp. that includes periodic ultrasonic inspection of vital mill equipment with emphasis on those parts for which spares are not available. The reflecting gage is being used mostly for the internal inspection of shafts, and the resonance gage for measuring plate thicknesses of tanks and other pieces of equipment that are not ac-

cessible from both sides or where measurements by other means are difficult to make.

In using the reflecting gage we advocate recording data at such vital points as fillets, keyways, etc., so that if changes occur at these points in the future, such changes will be recognized. This record should be in the form of a drawing showing the location on the end of the shaft at which the picture was made together with either a drawing or photograph of the indications on the reflecting gage screen. A similar procedure is advocated whenever flaws begin to develop so that their progress can be observed and repairs planned. Historical data cannot be overemphasized.

The use of the reflecting gage for detecting surface cracks has not as yet been satisfactorily proven to us. An example of this would be the detection of a crack developing at the root of a gear tooth. Where Mr. Rectenwald has stated that it is desirable to confirm surface fractures by magnetic particle or penetrate testing methods, we use the reflecting gage to determine, if possible, the extent of surface fractures located by other means.

I would appreciate Mr. Rectenwald's comments on the following two points:

1. Have you had any experience or do you have knowledge of any cases where ultrasonic instruments have either failed to detect flaws that existed or indicated flaws that were non-existant?
2. Is the resonance gage recognized by the state as an acceptable means of conducting boiler drum and pressure vessel inspection?

R. L. Rectenwald: In answering Mr. Matthew's first question, I believe the paper pointed out one application where it was possible to overlook a flaw which did exist. I do not believe it is very often the case that flaws will be indicated which are not present. However, the severity of the flaw would rest with the judgment of the operator or the stress analyst who was analyzing the information gained.

We have found flaws in large crankshafts in some of the internal areas where the forging operation was not properly executed, but at the same time these flaws were not in critical areas, so that actually they would be of no significance in appraising the value of the crankshaft. It is well to know that the flaws exist for a historical record even though they may not be serious at the time.

On the second point, I think that the point that insurance inspectors and insurance underwriters have purchased both instruments for their own inspections, does indicate their anxiety and willingness to use the instruments in boiler inspection work. Usually, the Boiler Code Committees allow the local inspector to pass judgment upon the case in question, so that if the indications were not very clear or very definite, the boiler inspector would probably not accept the indications.

In some cases we have known where they have made test drillings to check maybe five per cent of the total points inspected with the resonance gage, and after a few experiences of that type, have accepted all of the gage indications where they were very definite and clear readings.

I think in all cases, the final decision on whether or not the readings are accepted would be left to the judgment of the individual inspector on the job. There is no blanket approval or disapproval by the underwriters or the inspectors.

W. A. Black: The paper is so comprehensive that it really leaves little to be added. Republic Steel Corp. has been using ultrasonic instruments for about nine years now, and I think that perhaps that is ample evidence of the faith we put in these devices.

I might suggest or emphasize the point already made by Mr. Rectenwald that equipment drawings must be available in order to make an intelligent analysis of the indications of the instruments in maintenance work.

A word of caution might be added. If you have been using the instrument as it was first used in the steel industry, that is, for production inspection of blooms and billets, your men are accustomed to rejecting parts or components for extremely small defects. Such defects are as a rule entirely harmless for the majority of maintenance uses.

This is somewhat in line with the question raised by Mr. Matthew, as to whether or not you fail to detect defects or get defect signals when no defect is present. A variable that might cause a signal and be classed as a defect on metallurgical inspection could be entirely harmless and therefore no defect from the maintenance point of view. In one such experience, the metallurgical inspector rejected a machine component on the basis of his standards. When the component was cut up, the defect was so small that the maintenance superintendent was properly scornful of an instrument that would reject perfectly good and usable machinery. Considerable judgment is required in making a decision in such cases.

Another item I wanted to emphasize was that many materials will not transmit any signal at all. Mr. Rectenwald did mention that in his paper, but it should be recognized that many materials cannot be inspected by this method of test.

I am interested in knowing, Mr. Rectenwald, if you have found that the safety aspect, the safety engineer, has played much of a part in the acquisition of this equipment or its use?

R. L. Rectenwald: In regard to the safety aspect, I think one of the most shining examples is the organization at the Carbide and Carbon Works in South Charlestown, W. Va., where the inspection work comes under the jurisdiction of the safety department. The safety department sets the frequency of inspections of all critical equipment in the plant, including pressure vessels and engines, piping and like equipment. They have their own operators, and the operators report directly to the safety department.

I do not know of any similar organizations in the steel industry, but I do think that it is closely associated, or should be closely associated with the safety department functions. We have observed that the technicians trained and entrusted with the responsibility of routine maintenance inspection, express more pride and interest in the inspection program than the research engineers who are called out of their laboratories to make an occasional inspection usually under adverse field conditions.

Samuel B. West, Jr.: Do paint films on the outside of tanks or pipes have any influence on your readings?

R. L. Rectenwald: Yes, they do have an influence. Sometimes readings can be obtained without removal of paint, but it depends on the thickness of the coating and the density of the coating, the adherence, etc. We usually file or grind clean spots where an inspection is to be made.

Samuel B. West, Jr.: Can your instruments be used to inspect plastics, like bakelite, and some of the rubber-type plastics?

R. L. Rectenwald: I personally have not had any experience with those applications. However, I am certain that both instruments will work satisfactorily on homogeneous materials of that type, where they are relatively dense and of constant physical characteristics.

S. M. Matthew: If it would work on plastics, why does it not work on cast iron?

R. L. Rectenwald: Cast iron is not a homogeneous material, and composition and grain structure varies quite radically within one casting. That is, the density will vary, so that it actually absorbs sonic energy at varying degrees.

George French: Have you used this instrument to inspect railroad car axles? I have particular reference to roller bearing journals, where on certain designs, the small fillet that backs up the bearing is too small, and it acts as a bad stress raiser, so that you get gradual fatigue cracks.

Can you test from each end of the axle, thus avoiding the back reflection that you speak of, which might obscure the results? That is, can you test from one end of the axle toward the gradually increasing diameter, and then test from the other end to get the other reading?

R. L. Rectenwald: I am sure the reflecting gage would be preferred in that application, and I do not just recall the details of the designing of the axles. There may be some interference in some of the shoulders or fillets, which would preclude the inspection of the particular area you have in mind.

George French: These are axles used on rolling stock and have roller bearing journals. In the particular case I have in mind, the inside shoulder of the bearing was against a large diameter on the axle, of course, but the fillet which made the transition from the back-up shoulder diameter to the smaller diameter on which the bearing was placed, was too small and acted as a stress raiser, so that we obtained transverse breaks through the axle.

R. L. Rectenwald: That should be a very ideal application, because from what you say you would not pick up a back reflection at that point. But if there were a fracture there at all, it would be indicated.

George French: How about doing that job with the axle completely assembled, except taking off the cap end off the journal?

R. L. Rectenwald: It would be just as satisfactory, I believe.

Ralph H. Frank: It is more difficult and would likely require a special searching unit. Are the axles hollow?

George French: No, solid.

Ralph H. Frank: The problem is to get the sound into the area that you wish to test. If the wheel seat or the bearing seat is raised, this is difficult testing from the smaller end (diameter). What is the shape of the axle?

George French: Well, the end of this axle is about four inches at the threaded part where the nut will retain the bearing, and then at the part where fractures occur it is about five and three-quarters.

Ralph H. Frank: You would require a search unit with sound entrance angle of about 10 degrees. We have specially built such search units to fit on the end of the axle and direct the sound at the proper angle. Most of this work has been done with railroads, and the New York Central, I believe, has had field experience in such axle testing on diesel locomotives.

Joseph A. Marland: Mr. Matthew asked Mr. Rectenwald a question on the gear tooth application. I did not quite get the limitation that might occur with gear tooth checking.

R. L. Rectenwald: Well, these were cast pinions which I was referring to.

Joseph A. Marland: I was referring particularly to the more heavily stressed machine tooth, machine gears, cut gears.

R. L. Rectenwald: The one in particular which I was referring to is the steel mill pinion. Now, the difficulty we have found in the rough castings was that there was so much interference in the root, which was not machined at all, or not even worn smooth, that it interfered with the location of any fracture there.

With a machine gear, I think that if these surfaces were large enough to accommodate the flat surfaces of the search crystal, that it would be possible to locate that.

Ralph H. Frank: Yes, that is a very good application for an ultrasonic inspection, and usually the gear could be tested in place without cleaning. The sound path is along the surface, down through the root and back up the leading edge of the next tooth. Any indication between the point of contact and the edge of the next tooth would be a surface imperfection at the root.

Joseph A. Marland: What about the limitation on bronze worm gears?

R. L. Rectenwald: I think size would probably govern there.

Joseph A. Marland: Well, the pitch might be in the order of, say, from two diametral to probably three diametral pitch in many of the cases that I have in mind, and that in turn would be, that number of teeth per inch of pitch circle or pitch diameter.

Ralph H. Frank: I do not think that would be a good application. Small gears generally are not suitable for ultrasonic surface inspection, although a small search unit which can test pinion gears inside the journal box on diesel locomotives has been designed and used by a large manufacturer. As Mr. Rectenwald pointed out, however, large mill pinions and similar gearing is where the surface type inspection can be used to best advantage.

Economy Realized through strain gage checks

By R. P. GIBSON
Field Engineer
Republic Steel Corp.
Buffalo, N. Y.

. . . . strain gage checks showed that it was not necessary to replace as much structural steel as had originally been expected from computations . . . .

▲JOINT efforts on the part of an engineering department and electrical research department resulted in a saving of almost 75 per cent in the amount of structural steel originally considered as necessary for replacement in an open hearth charging floor. Using a team combination of designers and electronic experts with a modern application of an old principle, strain gage measurements were taken on the structural members. Simple wire elements cemented to girders under actual operating loads constituted the basic materials used in testing. Electronic amplifiers and oscillographs boosted and recorded the strain on the open hearth charging floor girders. The oscilloscope is an instrument for determining the form of a-c waves. It consists of a galvanometer having a moving system capable of extremely rapid vibration, fitted with a suitable arrangement for recording the vibrations. The deflection at any instant is practically proportional to the current flowing through it at that instant, in spite of the fact that the current may be varying very rapidly in strength and direction. It must be critically damped, as any tendency to overshoot would distort the wave from its true shape. In such a manner actual field measurements were allowed to determine the stress dimensions in charging floor girders. Such structural member tests were made necessary by the sustained increase in open hearth furnace production.

Fifteen years of record steelmaking production in the Buffalo shop had swelled tonnage. All material handling facilities had been enlarged to help create this increase in production. Overhead cranes had been rebuilt to increase load carrying capacity and, as part of the effect of increasing furnace tonnages, by 1950 all the crane runway girders had been replaced with heavier sections.

Two of the three 5-ton charging machines had been doubled in capacity by 1952, and each charger assumed about 25 per cent more weight for this new 10-ton capacity. In addition, charging box capacity had increased in volume from 20 to 36 cubic feet. Over and beyond an extensive floor beam replacement program and direct replacement of several open hearth charging floor girders damaged by furnace breakouts, no reinforcing or girder replacement program for open hearth charging floor girders had been attempted. This increase in productive open hearth capacity resulted directly in an engineering study to evaluate the dependable strength of the existing open hearth charging floor girders. The stresses on all the charging floor girders were computed on the basis of the maximum loading conditions that were possible with the two 10-ton chargers. Girder strength calculations were based on the following assumptions:

1. Girders acted as simple beams.
2. There was no interaction between adjacent girders by connecting floor beams.

Concurrently, the girders were tested for safe working loads wth electric strain gages.

Five years ago, any testing of structural members for actual load stresses would have been difficult because strain gage instrumentation was still in the development stage. In this respect, the Buffalo district was fortunate in having available both the technical experience and improved instrumentation developed earlier by our electrical research laboratory at Cleveland.

The initial discovery of the principle of strain gages, dates back to 1856 when Lord Kelvin investigated the effects of tension on electric conductivity in copper and iron wires. He concluded from experiments that copper and iron wires increased in resistance when loaded, and that the iron wire showed a greater increase than the copper. In this manner, Kelvin discovered the strain sensitivity of wires. By introducing the strain gage into a simple Wheatstone bridge the change of resistance

can be recorded. The sensitivity or gage factor of a gage is defined as the ratio of the fractional change of resistance to the strain producing it.

Gage manufacturers provide gage factor values with each different metal type gage.

Hooke's Law states that the stress set up within an elastic body is proportional to the strain to which the body is subjected by the applied load.

The electrical strain gage as used today is a thin metal wire cemented to a paper carrier so as to form a measuring element for surface deformations.

The strain gage is cemented to the structure to be tested and the elongation or compression in the surface of the structure is duplicated in the cement, the paper, and the wire of the gage. The deformation of the gage wire changes the wire's resistance and this change is recorded.

In order to test the girders at points of maximum bending, the distance from girder columns to point of maximum bending (maximum stress) was determined by the engineering department. Ten gages were used on the girders to test the different girder combinations. Smooth rust free girder surfaces were required before installation of gages to girder. The gages were applied to the underside of the flange of the girder with cement, permitted to dry 24 hours and were used immediately after the drying period. The following instruments were used by the members of the electrical research laboratory in making the strain tests.

1. Amplifier.
2. Dual channel oscillograph.
3. Strain indicator.
4. Ohmeter.
5. Dummy gages.

Strain gage connecting cable was two conductor, No. 16 RWG, rubber covered, stranded lamp cord.

The procedure during the actual testing was to reproduce the conditions of maximum loading and to have two chargers (we have one 5-ton charger between two 10-ton chargers), the north 10-ton charger, and the 5-ton charger travel bumper to bumper over the girders in the north charger shop area. The chargers traveled both directions over any girder under test. Similar test conditions were used with the south 10-ton charger and the middle 5-ton charger over the girders under test in the work area of the south charger. An observer on the open hearth charging floor transmitted by telephone to the recorder in the open hearth cellar, an eye witness account of the direction and position of the open hearth charger. Items such as scrap on track, or an open rail joint, produced high impact stresses and were recorded on oscillograph chart paper. Shop production continued during tests.

Final stresses were tabulated and compared with the original calculated stresses in the girders. Fewer girders were replaced on the basis of the measured values than on the calculated values. The apparent discrepancy between the gage measurements and calculated stresses is believed to be attributed to initial assumption errors. Structural members in the Buffalo open hearth shop act as continuous beams and are further strengthened by interaction with other girders through connecting floor beams.

SUMMARY

These measurements of stress on the open hearth charging floor girders demonstrate the tremendous advantage of actual measurements over assumptions and calculations based primarily on theory. In some instances the measurements may save money and in others they may demonstrate a need for additional strength. In all cases when correctly used they provide the engineer with a sounder basis from which to project his design or improvement.

Teamwork between the engineers of many different types is needed in order to achieve the maximum return from instruments. The use of strain gages in this open hearth study is a good example of this kind of teamwork.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Metallurgical Aspects of Plant Maintenance

By T. G. BRADBURY
Laboratory Supervisor
The Steel Co. of Canada, Ltd.
Hamilton, Ontario, Canada

. . . . a good understanding of the properties and characteristics of materials is essential in the economic maintenance of equipment . . . .

▲ IN the search for the most suitable material to do a particular job and in trouble shooting on plant equipment failures, the investigator must consider such matters as heat treatment, welding machinability, casting procedure and many fabricating methods. His chief concern, however, will be choice of material as he encounters problems involving repeated failures due to stress, wear, corrosion, heat, etc., and he may choose from a wide range of material, both ferrous and nonferrous. In addition to the wide range of carbon and alloy machinery grades of steel which find their way into shafting, axles, gears, etc., he is likely to be investigating such material as cast steels, cast irons, tool steels, high-speed steels, bearing metals, stainless steels and other non-corrosive and heat-resisting alloys.

On many occasions the metallurgist will find that he must desert his field and trespass into the mechanical aspects of the problem because a surprisingly large percentage of equipment failures are due to mechanical causes, although the tag on the broken part sent in for investigation reads, "What's wrong with this steel — can you recommend something better?"

In this paper examples of faulty material, poor choice of material, poor design and heat treatment and weld failures are presented. Considerable attention is given to the control of materials used in lifting equipment and in most large scale industrial operations there is considerable scope for such a program.

It has been the experience of the writer in investigating the failure of lifting equipment, that casual

Figure 1 — Martensitic structure was formed at the torch edge of "C" hook. Magnification about 100X.

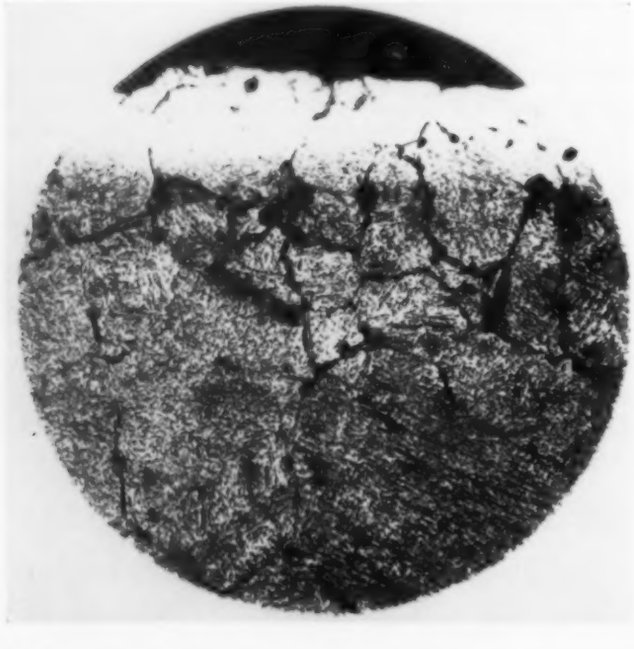
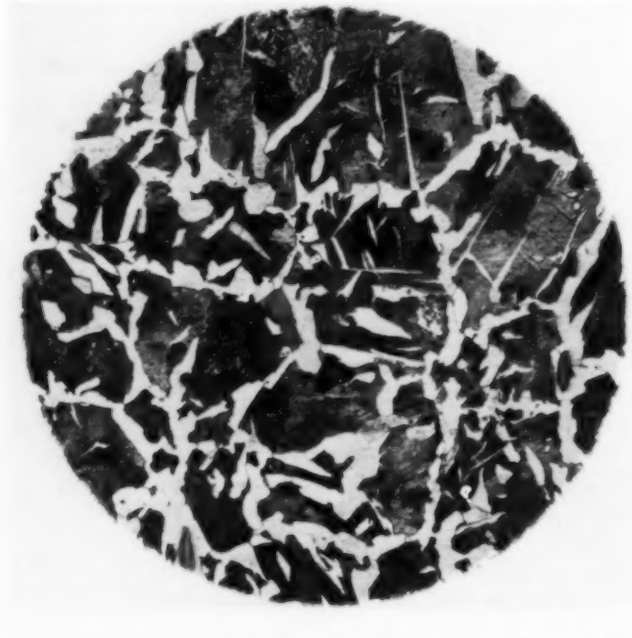


Figure 2 — Micrograph shows normal structure of steel in "C" hook away from torch cut edge. Coarse structure should be normalized to improve ductility.



attention to material choice, lack of heat treatment and indiscriminate welding in manufacture and maintenance are generally responsible. Listed below are several examples of these contributing conditions in failures actually encountered:

"C" hook failure — Failure due to flame cutting. The bale had been flame cut from a 4-in. plate slab with the result that a flame hardened edge had been developed due to chilling by adjacent cold metal. This led to incipient cracking and eventually complete failure. The carbon content of this steel was 0.41 per cent. See Figures 1 and 2.

Open hearth slag pot bale failure — The fracture took place at the weld joining the handle to the side of the bale. The investigation revealed that cracking had started in the hardened zone immediately beneath the weld. The steel contained 0.56 per cent carbon and was in the as-forged condition.

Open hearth slag pot bale failure — The investigation revealed that the part was made of 1045 steel and was in the as-forged condition, consequently the properties of the steel, particularly toughness and ductility, were poor. These conditions, along with a sudden change in section and poor fillet profile, were responsible for failure under possible side or twist loading.

Annealing furnace bale failure — Under zyglo inspection this bale showed seven cracks developing in one set of legs. The size of these cracks ranged from ½ to 1½ in. in length. The bale was scrapped.

Flat coil lifting hooks — Zyglo showed three cracks developing from forging laps. This hook was removed from service and scrapped.

Crane runway overhead suspension bracket — Examination of the suspension bar which failed at the bracket holding the crane runway, revealed it had been made of high-speed steel. Such material is, of course, entirely unsuitable for the purpose and was undoubtedly the result of error rather than choice.

Ladle tilting ring failures — The rings were forged from 2½-in. bars and are elliptically shaped 8 in. × 20 in. All rings showed extremely coarse fractures with no necking down and, although there was considerable surface work hardening in evidence, there was no noticeable deformation of the rings prior to breakage. Micro-examination revealed as-forged structures of gross coarseness. It was apparent that the material had extremely poor impact strength and offered little resistance to shock loading. Improvement resulted from normalizing heat treatment.

These investigations have revealed that in the case of bales and hooks which failed due to torch cutting and welding, the use of relatively high carbon steel was directly responsible for failure because of high hardenability inasmuch as preheating was not given.

In those failures which did not involve welding, poor ductility and poor resistance to suddenly applied loads was responsible, due to the omission of a structure refining heat treatment. The use of relatively high carbon steel, presumably to achieve higher tensile strength, was unfortunate in the absence of the normalizing treatment, and the incredible case of a bar of high-speed steel being used in lifting equipment will alert all concerned to the importance of careful attention to material choice.

It would appear that the prime requisite in lifting bales, apart from being capable of supporting the nominal calculated load, is the ability to deform under abnormal overloads which are occasionally encountered in service, thereby giving warning that the part has been damaged. If sufficient ductility is not provided to permit bending, it is possible that, if the part does not fail completely under abnormal loading, it may become partially cracked and therefore, fail under some subsequent normal lift. With this in mind, the superiority of C-1020 over the medium carbon grades (represented by C-1050) in normalized 4-in. sections, is illustrated, and the part should be designed so as to make the lower tensile strength of C-1020 adequate. See Table I.

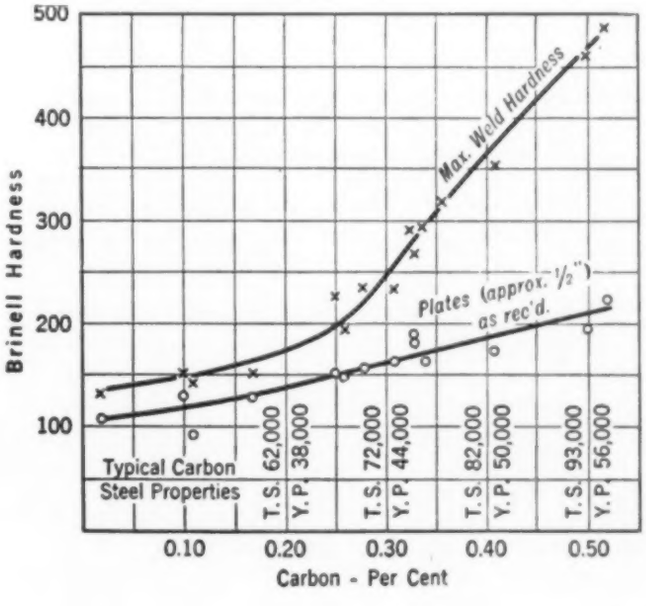
TABLE I

Grade	Yield strength, psi	Ultimate strength, psi	Elongation, per cent in 2 in.	Reduction of area per cent	Brinell hardness	Izod impact ft-lb
C-1050	55,000	100,000	22.0	42.0	201	22
C-1020	42,000	60,000	37.0	65.0	121	80

In addition to the substantial increase in ductility and resistance to impact which would result from the use of the lower carbon steel, weld hardening would be virtually eliminated. This is particularly important because, although an attempt may be made to prohibit welding on bales and hooks, the possibility of apparently innocent welding repairs being carried out on location, is quite likely. The failure of the open hearth slag pot bale typifies the kind of welding which, to the millwright, must seem insignificant. The weld which caused this failure merely fastened a handle to the side of the bale. It caused weld hardening which led to failure.

Failures in service of lifting equipment are alarming, to say the least, and results of the investigations outlined emphasize the need for a firm policy regarding the materials, maintenance and inspection of bales, hooks, rings, clevices and pins and other lifting parts. The following specifications would be worth while:

Figure 3 — Carbon content in plain carbon steels affects amount of weld hardening.



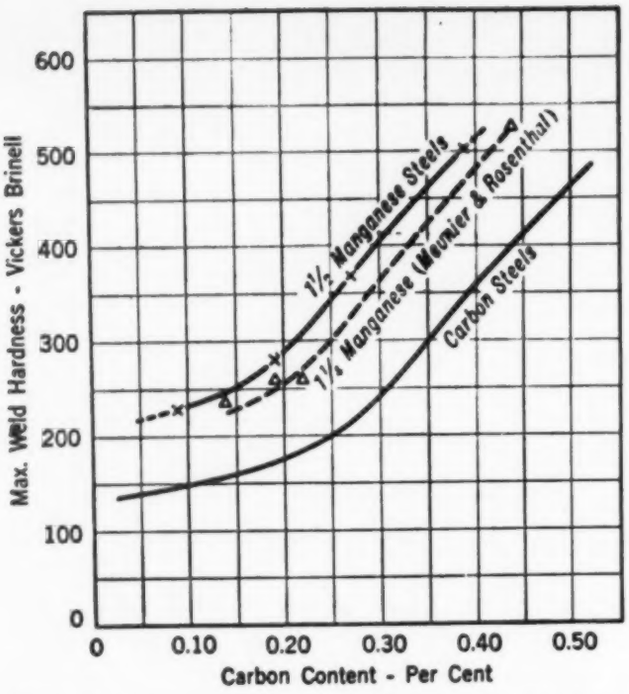


Figure 4 — Curves give maximum weld hardness in ½-in. plates from surface beads deposited at about 5 in. per minute with heavily coated 3/16-in. electrodes.

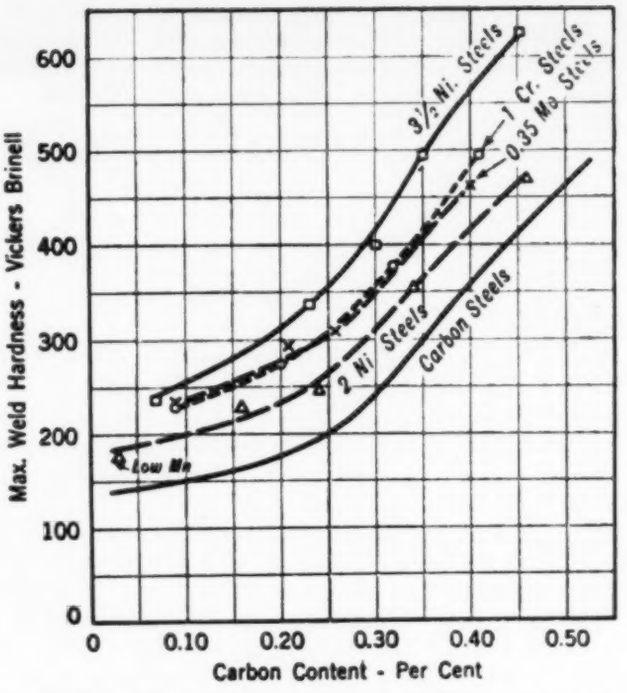


Figure 5 — Curves give maximum weld hardness in ½-in. plates from surface beads deposited at about 5 in. per minute with heavily coated 3/16-in. electrodes.

Material — The steel should be AISI 1020. It should be deoxidized with aluminum to promote fine grain with attendant higher impact strength, particularly at low temperature, and as a precaution against aging. The McQuaid Ehn grain size should be 6 maximum.

Fabrication — Forged bales and hooks should be normalized at 1600-1650 F. If welding is used in fabrication it should be carried out prior to normalizing. Preheating should not be necessary on 1020; however, if practical it is a worthwhile precaution.

should be magnaflux or zyglo inspected after forging for the detection of forging laps, cracks or other similar defects.

All such parts should be subjected to this type of inspection at regular intervals. It is felt that six month inspection is not too frequent. In this regard, a numbering and catalog system of all parts would assist in keeping records of inspection and normalizing treatments.

Samples of the steel to be used in the fabrication of

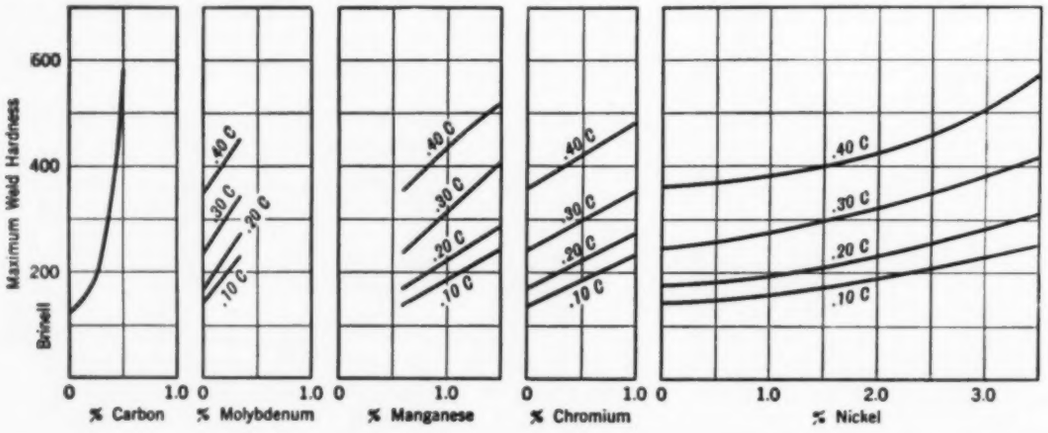


Figure 6 — Chromium, molybdenum, and nickel have different effects on weld hardenability, with the greater effect accompanying higher carbon contents.

Maintenance — Surface embrittlement due to cold working is common under conditions of metal to metal contact and regular periodic normalizing at 1600-1650 F should be provided in order to remove effects of work hardening and aging. Low temperature annealing should not be attempted for the purpose of removing cold working as such treatment, below the critical temperature of the steel, will probably promote severe grain growth and the danger of Stead's brittleness.

Inspection — All bales, hooks and other lifting devices all new bales, hooks, etc. should be examined and tested by the metallurgical department, and be subject to its approval.

Weld hardening — The term "weld hardening" has been mentioned several times in the foregoing discussion of failures in lifting equipment, and it is certain that most maintenance people are familiar at least in a general manner with the condition. Nevertheless, weld failures directly caused by underbead hardening continue to occur because of complete disregard for the

parent metal and its hardening power. Indiscriminate welding in plant maintenance is after all understandable because the method is an ever ready and handy method of fastening and fixing, and as such, the tool falls into many hands.

To those who know something about hardenability and heat treatment of steel, weld hardening is no mystery for, after all, to weld a piece of steel is to heat treat it locally. The highly heated zone immediately beneath the bead is quenched by adjacent cold metal frequently with greater speed than with the water quench used in tool hardening. Large pieces of parent metal have greater quenching power than small pieces and therefore, the cooling capacity of the part must be considered when welding the high carbon or alloy steels because of the relative ease with which such grades will harden.

One particular failure is used by way of illustration. It concerns an electric locomotive axle on which the bearing collars became loose. Quick repairs were made by securing the collars by four seemingly innocent tack beads about one inch in length at 90 degree points about the circumference of the 7-in. axle. The axle was made from C-1050 containing 0.51 per cent carbon and 0.88 per cent manganese, and the quenching power of an axle of this large size at summer atmospheric temperature (job was done in August) on a medium carbon steel proved to be drastic. Fully hardened martensitic structures were formed beneath each tack weld. Under bead cracking occurred and fatigue cracks soon propagated to cause complete failure of the axle in service.

The influence of the factors involved in weld hardening are presented in the graphs, Figures 3 to 9, which were produced by H. J. French and T. N. Armstrong in their paper "Weld Hardening of Carbon and of Alloy Steels." This data shows the influence of carbon and alloys on the extent of weld hardening. The chilling effect by the mass of the parent metal is indicated and it will be seen that slower welding speeds reduce weld hardening simply because slower arc travel means more heat input and correspondingly slower cooling rate in the heat affected areas, Figure 7. Of particular interest is the graph showing that preheating can reduce weld hardening to a safe level, Figures 8 and 9.

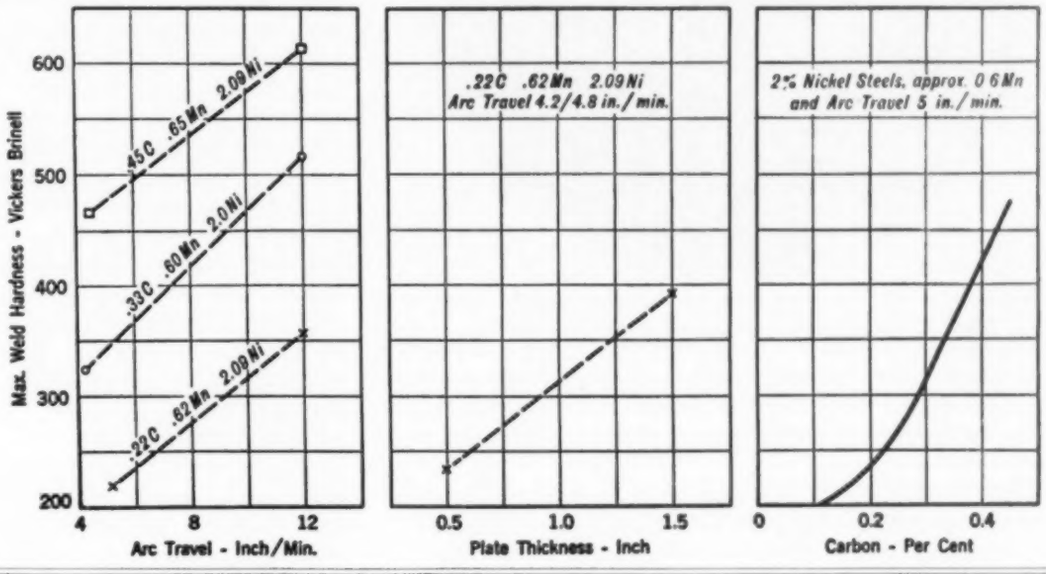


Figure 7 — Weld hardness of 2 per cent nickel steels is affected by arc travel speed, plate thickness, and carbon content.

PROGRESSIVE FATIGUE FAILURES

Fatigue failures continue to account for ninety per cent of all breakages of axles and shafting. Failures of

Figure 8 — Curve shows effect of precooling from 5 to 10 F on the maximum weld hardness of several types of steel. Tests were made on ½-in. plate welded at 5½-in. per minute.

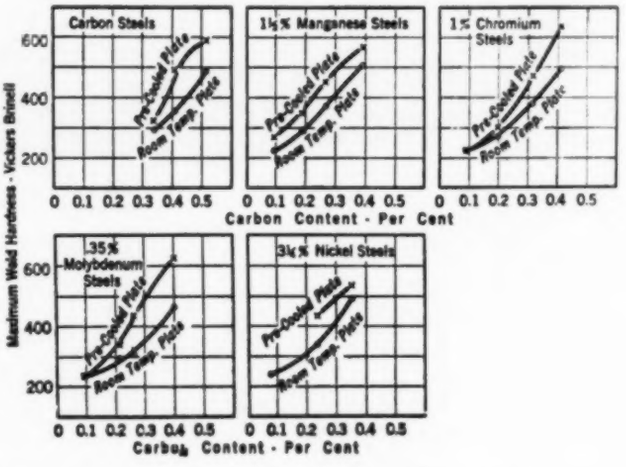
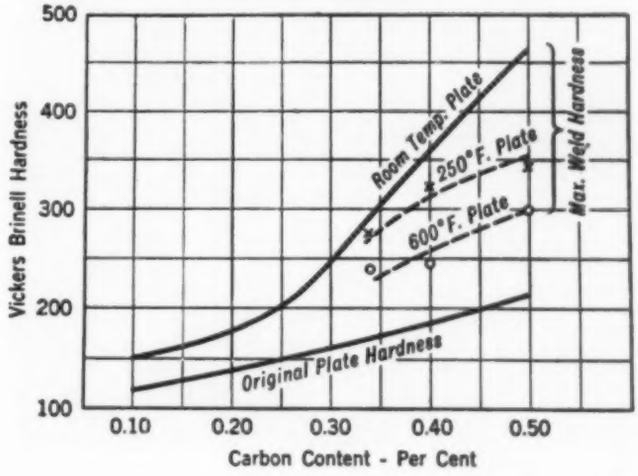


Figure 9 — Preheating has a definite effect on weld hardening in ½-in. carbon steel plates.



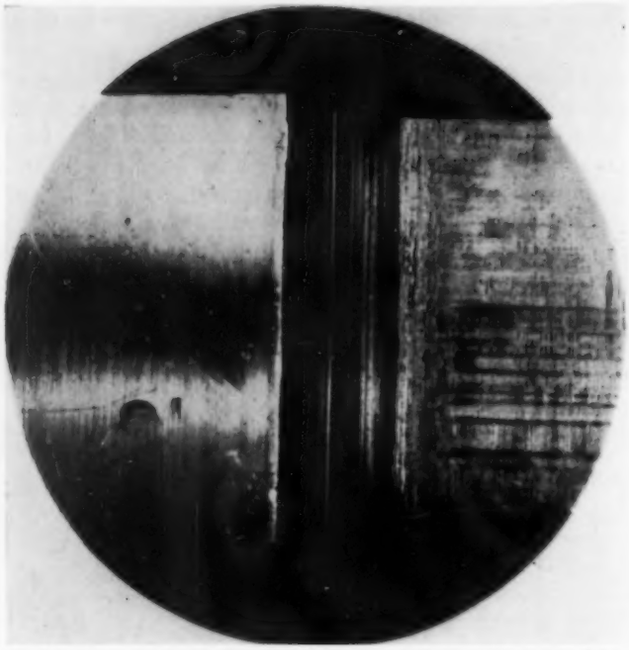


Figure 10 — Segment at skip axle shows rough machine fillet at the section step down. Magnification 3X.

this type occur because of stress concentration at the surface of the part, and the source of the fracture can usually be traced to some form of notch or rough surface condition.

There are literally hundreds of types of stress raisers which can result in fatigue failures but the least obscure of all, and yet still the most common, is the sharp roughly filleted change in section on the common axle shafting. An example is shown in Figures 10 to 12. The part involved is an axle from an ore skip operating in an inclined shaft. Repeated failure had taken place in these axles at the change in section provided for the press fitting of the wheels after handling about 400,000 tons. The original design called for a most inadequate fillet, and the metallurgical department recommended that a more generous one be used.

Little improvement was realized, however, by this change in design and premature failures continued. An unbroken axle was removed from service after handling a very small tonnage and, as the illustrations show, although a substantial fillet had been provided, the workmanship was exceedingly poor. A segment cut from the axle and polished on the longitudinal axis revealed that fatigue had already commenced at the base of the roughly machined fillet at a point which had actually been undercut by the machinist. When polished fillets were finally achieved in these axles, it was found that one million tons could be hauled before inspection for crack detection was necessary.

Most plant operations involving heavy lifts employ wire rope of one type or another, and such cables are subjected to various degrees of abuse. Such abuse is easily recognized and freely admitted as being undesirable. Individual wire failures occur, however, on rope the operation of which appears smooth and relatively non-destructive. These are usually typed as fatigue failures and are accepted as being normal. Metallographic examination of such wires frequently will reveal that surface layers of the micro constituent martensite approximately 0.005 in. deep, are associated with the crown wear.

Martensite is the product of steel quenched from above the critical temperature and its presence on wire rope simply means that service conditions have been such that the superficial skin of the wire has been raised to some temperature in excess of the critical, and subsequently chilled by the adjacent cold metal within the wire. Martensite has no ductility and cannot be bent without cracking, consequently fatigue readily develops as the wire passes over sheaves and drums.

The source of such trouble has been found in multiple layered drums where severe abrasion incurred by rope lifters and crossover points and the scuffling action

Figure 11 — Segment of Figure 10 is here shown with magnification of 10X. Crack can be seen emanating from undercut at base of rough fillet.

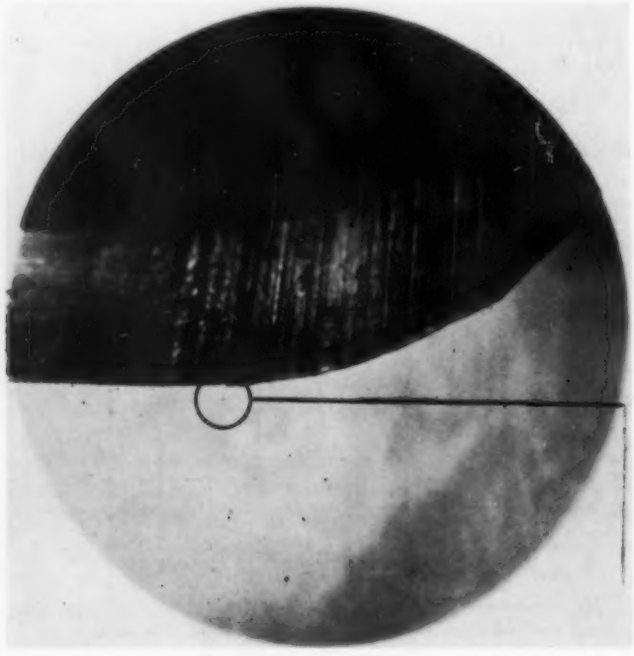


Figure 12 — Crack shown in Figure 11 shows up more clearly in this view which has a magnification of 30X. Notch effect started fatigue crack.

TABLE II

Molds	Heats	Total C	Graphitic C	Cementitic C	Si	Mn	P	S
No. 1 — 29 x 48¾	1 — Discarded	3.09	2.20	0.89	1.18	1.27	0.227	0.061
No. 4 — 29 x 48¾	1 — Discarded	3.13	2.48	0.65	1.69	1.95	0.246	0.061
No. 8 — 29 x 48¾	2 — Discarded	3.14	2.37	0.77	1.02	1.34	0.214	0.080
No. 9 — 29 x 48¾	1 — Discarded	3.22	2.56	0.76	0.79	1.26	0.159	0.054
No. 10 — 29 x 48¾	1 — Discarded	3.11	2.58	0.73	1.26	1.78	0.146	0.037
No. 1 — 26 x 53	1 — Discarded	3.16	2.56	0.60	1.27	1.68	0.178	0.042
No. 2 — 29 x 48¾	17 — Discarded	3.06	2.18	0.88	1.14	0.69	0.265	0.075
No. 3 — 29 x 48¾	40 — In service	3.01	2.05	0.96	1.18	0.70	0.260	0.087
No. 3 — 26 x 53	78 — In service	3.12	2.26	0.86	1.14	0.96	0.217	0.089
No. 6 — 26 x 53	26 — In service	3.02	2.38	0.64	1.42	0.93	0.150	0.092
No. 7 — 26 x 53	62 — In service	3.13	2.45	0.68	1.22	0.90	0.247	0.081
No. 8 — 26 x 53	26 — In service	3.14	2.41	0.73	1.36	0.89	0.272	0.075
No. 9 — 26 x 53	11 — In service	3.00	2.32	0.68	1.22	0.82	0.231	0.093
No. 10 — 26 x 53	20 — In service	3.09	2.33	0.76	1.00	0.76	0.244	0.100
No. 11 — 26 x 53	19 — In service	3.30	2.66	0.64	1.06	1.16	0.207	0.060
No. 12 — 26 x 53	13 — In service	3.09	2.31	0.78	1.04	0.75	0.230	0.081

between layers is most favorable to the formation of martensite. Surface friction created by the slipping of the cable may give localized surface heating.

FAILURES IN CASTINGS

The breakage of cast iron parts is in many cases taken for granted and most broken castings are discarded and replaced. Some of the larger, more expensive parts find their way to the laboratory for investigation. Two examples of the influence of iron composition and microstructure on the life of the part are presented.

The first case concerns the repeated failure by cracking of ingot molds after being used for only one or two heats. The failures appeared to be due to improper balance between total carbon, silicon and manganese, low total carbon and silicon, and high manganese having produced an iron of low graphitizing power, hence a steel matrix which was slightly hyper-eutectoid and brittle. The influence of the silicon-manganese content on the life of ingot molds made from cupola iron, is shown in Table II. All compositions shown, regardless of mold life, are low in graphitizing power and show high percentages of combined carbon. This condition, when aggrevated by high manganese contents, and particularly when the manganese was in excess of the silicon, led to early failure.

The effects of this "off composition" were shown in the structure at mid section of a broken ingot mold. The network tendencies of intercrystalline carbide in the steel matrix of the iron appear to account for the low resistance to thermal shock introduced during casting of the ingot.

An investigation was carried out to determine the reason for premature failures of the trunnions on certain cast iron cupola pots. The cast was permitted to solidify in these pots and the practice was to up-end them rather sharply in order to free the contents. This operation imposed considerable impact on the trunnions which were cast integral with the pot. Metallurgical examination of a trunnion which failed after only seventy-three fillings, and one which survived four hundred and twenty-five, revealed a very considerable difference in structure and properties. Although the iron in the trunnion which handled four hundred and twenty-five fillings is also a low strength grade, it exhibited a contrasting improvement over the one which gave poor service. In the latter the graphite flakes were particularly coarse and continuous, and had marked directionality obviously imparting exceptionally poor impact properties to the material. The tensile strength was only 11,400 psi as against 17,000 psi for the superior trunnion. Evidence such as this can be discussed with the supplier who, by attention to iron composition and foundry practice, can supply a superior product on future orders.

The problem of wear is ever present in most equipment parts and in the struggle against it a variety of engineering materials are available. In many instances, alloy steels are chosen for replacement and these are usually heat treated to a relatively high hardness. However, improvement in wear resistance from the use of such material is not usually substantial. Hard facing by welding frequently is very satisfactory because of the highly developed overlay alloys now available and because ready repairs can often be made on location.

Worthwhile consideration can be given to the use of the white cast irons and austenitic manganese steel for parts subject to wear. In choosing between these materials, the degree of impact present in service conditions is important. White iron is quite brittle and consequently not recommended for applications involving a considerable degree of heavy impact. Where this is

Figure 13 — Chilled white iron wheel section shows the chilled tread and flange area with mottled iron changing to grey in the hub areas.

Figure 14 — This fractured manganese steel mantle was removed from a cone type ore crusher.

largely absent, however, and under conditions of sharp abrasion, white iron is ideal providing a casting can be adapted.

In this metal the graphite flakes, which are so weakening and common to so-called grey iron, are converted to iron carbide, the hardest of all the micro constituents found in iron and steel. The carbide is in a particularly massive form and it is its presence that imparts such wear resistance to the alloy.

In the interstices of the columnar carbide is the relatively soft constituent pearlite which is considerably less wear resistant. The pearlite is changed to hard martensite, however, by the addition of 4.00-5.00 per cent Ni and 1.50 to 2.00 per cent Cr, most of the latter element alloying with the carbide for even greater wear resistance. The use of the Ni Cr white iron is usually worthwhile as evidenced by the increase in hardness, 600-650 Brinell for the Ni Cr iron as against 450 for the unalloyed type.

An example of the application of white iron is illustrated in Figure 13 which shows the trend and flange portion of a certain type of railway wheel. This happens to be a chilled variety of white iron, the composition of which is adjusted so that the portions of the casting rapidly chilled on the mold, possess the white iron structure. The unchilled portions remain grey and machinable which is advantageous for some applications.

For service involving a relatively heavy impact type of wear, austenitic manganese steel will provide a very satisfactory degree of wear resistance. This steel usually contains in the neighborhood of 1.00-1.25 per cent carbon and 12.00-14.00 per cent manganese. As the term implies, when properly manufactured, the steel is fully austenitic. This constituent is highly susceptible to work hardening and therefore, the advantage of using this steel depends largely upon whether there is enough pounding or pressure to produce a useful degree of hardness at the surface. Under suitable service conditions such as in crushing operations, the normal as-cast hardness of approximately 200 Brinell will be increased to as high as 500 at the surface receiving the wear, and as this wears away it is self renewed. Unfortunately this grade of steel frequently is used under abrasive conditions where impact or pressure are light. Its use is probably not justified for such service in most cases, as the Brinell hardness test on the worn out parts will show

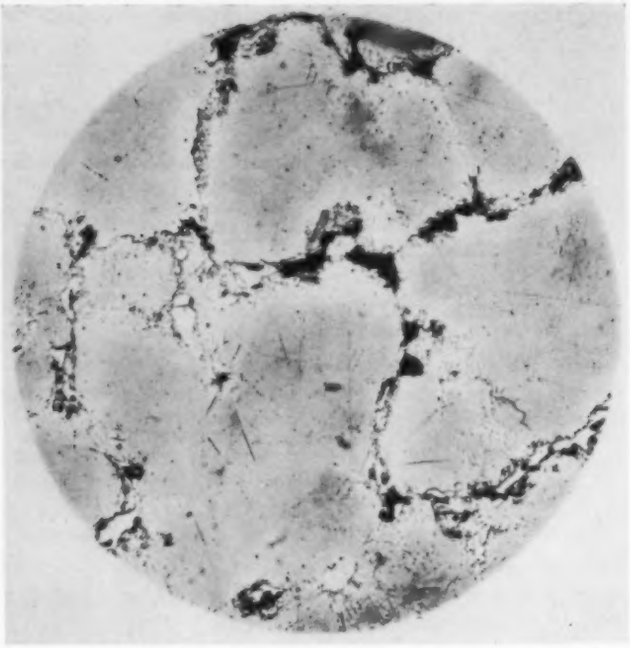


Figure 15 — Photomicrograph shows structure of mantle. Crack is seen to follow embrittling network of intercrystalline carbide. Magnification 500X.

little increase in hardness at the wearing surface.

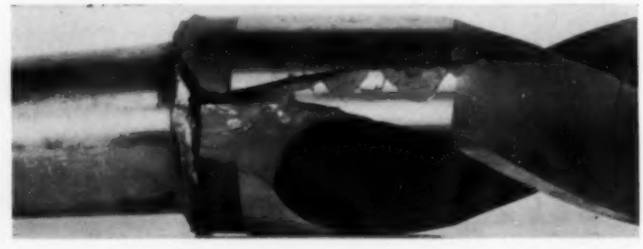
Properly treated high manganese steel normally represents steel in its toughest form and castings made to the best practice can withstand the hardest type of service. Failures due to fracturing occur, however, when manufacturing practices or service conditions are such that brittle intercrystalline carbide is permitted to precipitate from the austenite.

Figures 14 and 15 show a mantle which failed prematurely with a scrap metal loss of 67 per cent in a cone type crusher handling ore. A heavy network of embrittling carbide will be seen at the austenite grain boundaries along which the fracture has followed. This faulty structure was due to incorrect heat treating practice on the part of the supplier.

In our plant, track frogs have failed in service on the charging floor of an open hearth shop. Frogs and switches of manganese steel are successfully used on the railroads but, in this case, the frog was used immediately in front of the furnace, and the occasional breakout of molten metal which flowed over the track was sufficient to cause the austenite grains to break down into martensite with a serious embrittling effect. The danger of such structure can be reduced somewhat by the addition of 3.5 per cent nickel to the alloy.

Poor physical properties resulting from inadequate heat treatment account for a high percentage of failures

Figure 16 — A 2¼-in. twist drill failed during operation because of crack initiated from electric stencil marking.



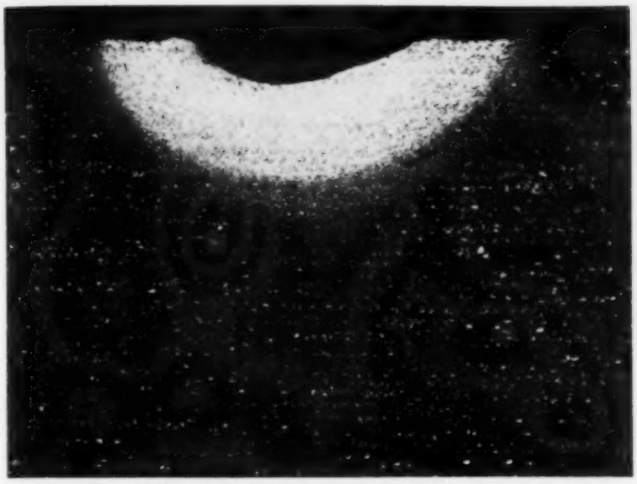


Figure 17 — Magnified view of twist drill shows localized hardening which resulted from electric stencil mark at surface of drill. Magnification 100X.

in heavy equipment parts. Large castings in particular are slow to respond to heat treatment and those containing alloy are especially sluggish. An example is a blooming mill roll coupling. This coupling handled only 550,000 tons whereas the expected life was 2,000,000 tons. The structure was characterized by dendritic segregation and was in sharp contrast to the superior structure of an identical coupling which produced 1,500,000 tons and is still in service.

The failure of a 44-in. blooming mill main drive spindle was investigated. One-half of the coupling at the mill end of the spindle had broken away after about ten to twelve months of service. The fracture exhibited a clean, regular break with no evidence of progressive cracking. However, it was rather coarse in texture. Micro-examination revealed a particularly coarse structure indicating complete absence of heat treatment. Small micro specimens taken from two new spindles showed a fine grain size typical of a good normalizing treatment. The superior properties as indicated by the structure of the heat treated spindles were obvious.

Making the carbide behave is frequently the problem in tool failures also, and this is shown rather vividly in the case of a 12 per cent Cr washer die which cracked longitudinally after producing only 500 washers. The highly directional nature of the carbide constituent appears responsible. It would be difficult to redistribute the banded carbide in the relatively short cycle heat treatment of the tool room, and correction therefore, lies in the hands of the producer.

Figure 16 shows a 2¼-in. twist drill which failed due to having been marked with an electric stencil for purpose of identification. The micro section, Figure 17, shows superficial hardened areas immediately beneath the stencil marks. This type of marking which employs intense localized heating on a steel having the hardening capacity of 18-4-1 high-speed can only lead to trouble.

A few fundamental examples of how the trouble shooting metallurgist can help the maintenance engineer have been set down and it is hoped that the value of such endeavors will be apparent. As the section on lifting equipment has illustrated, safety alone demands that certain metallurgical practices be adopted. Similarly in the economic maintenance of producing equipment, a good understanding of the properties and characteristics of the material is essential and in such matters the metallurgist can lend valuable assistance to those responsible.

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Pittsburgh (22), Pa.

By A. D. KING, Manager, General Electric Co., Cleveland, Ohio

Productive Maintenance

. . . . this is the positive approach to reduced production costs . . . .

▲THE use of electric power has doubled every decade for the past fifty years. Furthermore, this fantastic growth will continue far into the distant future. The population of these United States increased approximately 3,000,000 in 1953 and is expected to reach 170,000,000 by 1960. Steel, automobiles, appliances, and many other products hit production highs in 1953.

We are now entering a readjusting period. In spite of the economic realignment, product demands will increase over the years to come, and this increased production will have to be supplied without any appreciable increase in manpower.

Based upon the best analyses and predictions, the available manpower to supply the needs of an expanded economy will not appreciably increase during the next ten years. If these predictions are accepted as true, it is obvious that greater production, including more steel, will be required per manhour of labor in the days to come.

In order to accomplish increased production per manhour, it will be necessary to utilize present facilities to their maximum efficiencies and, likewise, install new and more modern facilities in order to produce more steel with the same, or even less, human energy expended.

The trend in industry today is to automation and cybernetics, both of which mean to the ordinary layman processes for producing more goods with less human energy.

In order to accomplish a greater rate of production per manhour, it will be necessary to utilize all facilities at optimum production without interruption, breakdowns, or schedule disturbances. Uninterrupted production can only be achieved by following a well organized and planned productive maintenance schedule.

A productive maintenance schedule, in reality, is the positive approach to more efficient and more productive operation with present facilities and, likewise, increased production with expanded facilities.

In order to accomplish the most fruitful operations, it is necessary for management to recognize the maintenance department as a true partner of production in the business of producing steel. This recognition must, also, be augmented with the necessary authority for the maintenance department to carry on the colossal job of maintaining the mill equipment.

After you have given your maintenance department full recognition and full authority, then they must follow specifications for a productive maintenance program. These specifications call for an intelligent, positive approach to mantaining the mill equipment. What are the ingredients for a sound productive maintenance program?

First—An adequate staff of trained maintenance men is absolutely necessary to carry on a fruitful productive maintenance program on modern day equipment. This staff of men must consist of capable electrical and mechanical engineers and mechanics who have a complete working knowledge of all equipment in the plant. These men must be fully qualified to thoroughly test, inspect, and even make repairs on the many different types of equipment for which they are responsible.

"From where can such men be obtained?" In the first place, men assigned to the maintenance department should be placed there because they are fully capable, qualified, and even desire to work at that class of work. They should not be put there because they are not suitable for other departments. The best approach for having the men available to carry on a productive maintenance program is to develop them through a training program right in your own plant. It is true that this development period will take time. However, as such men are developed, they will be able to render an invaluable service to your organization.

Second—The maintenance staff must know the true productive worth of your plant equipment. With this knowledge, they will immediately accept a productive interest in the operation of the mill. If your maintenance people recognize that the outage of a machine is costing the company so many thousand dollars per hour, it cannot help but create enthusiasm within themselves to get the machine back in line as quickly as possible or further still be on the alert to prevent machines from dropping out of service.

Third—The maintenance department must be fully equipped with the necessary tools to carry on an intelligent maintenance program. By tools, we mean instruments, measuring devices, records, engineering data, specifications, and even the more or less guarded secrets about production schedules and mill capacities. An alert maintenance department armed with the proper tools and information will be able to do a much better job of properly maintaining your mill equipment.

Fourth—One of the most important prerequisites of a well balanced and operated maintenance program is that of a very complete record system of all equipment

in the mill. A record card should be maintained on every piece of vital equipment in the plant. These record cards should carry the complete rating of the equipment, its productive value to the mill, a complete list of renewal parts, and their availability and location in the store room in order to facilitate immediate repairs in case of an emergency.

These cards, likewise, should carry a historical record of each machine so that the maintenance superintendent can take a look and determine the frequency rate of trouble on different types of equipment. If the frequency rate is greater and more severe than thought necessary, obviously an engineering investigation would be in order to determine if the correct equipment has been applied to the job, or if it is being incorrectly used or improperly maintained. Furthermore, the maintenance record should record all tests, inspections, and even the cost of maintaining the equipment in question. You might be surprised to find the amount of savings that can be uncovered by maintaining an accurate and complete record system on your equipment.

The most important ingredient of a productive maintenance plan is the program itself. In order for a productive maintenance program to be wholly successful, it is necessary to maintain a continuous inspection and testing program by men that are thoroughly trained and capable of detecting impending trouble, men that are sufficiently experienced to understand data collected by instrumentation, measuring devices, temperature recordings, even troubles in the infant stage that may cause undue noises or vibrations. The testing and inspection program, in reality is the watch dog for the maintenance program.

The inspection and test must be carried on, on a very rigid, predetermined schedule and after the data has been compiled and analyzed, obviously minor repairs should be taken care of immediately and impending major repairs must be scheduled at the first opportunity at which time they can be handled without interfering with the production schedule of the mill. This is the big asset of a productive maintenance schedule, detecting before it occurs, planning for the repairs at a time that it will not interfere with mill production. Planned outage will result in much less production loss than the unplanned outage.

The unplanned outage always occurs when the mill is being pushed to its maximum capacity to fill an order that is much in need. This is the most costly type of an outage that can possibly occur. In addition to losing the productive value of the mill, the usual costs of the repairs are much greater than they would be on a planned basis as one will be required to resort to most any method to get the mill back in operation. Consequently, caution, engineering, and maintenance costs are thrown to the winds and the mill is made ready at any cost to complete the order.

Rigid inspection and a planned, scheduled procedure for carrying on the maintenance repairs to equipment, will maintain mill equipment for optimum production. This production will be achieved with fewer manhours per ton of steel than would be the case if you were continually having intermittent failures and production stoppages.

In the area of equipment maintenance, mill operators all recognize that the three major enemies of mill equipment and continuous and uninterrupted operation are dirt, heat, and poor maintenance.

Dealing with these culprits individually, dirt causes undue wear on mechanical parts that will develop into early equipment failures. Dirt restricts and contaminates lubricating oils which cause bearing failures that, in turn, can result in serious machine damages. Dirt restricts and contaminates coolants, allowing equipment to operate at excessive temperatures which, again, is encouraging equipment difficulties. Dirt restricts air circulation in addition to contaminating the very cooling airs that are needed to keep equipment at its normal operating temperature. It, also, establishes electrical paths that result in the failure of contactors, motor windings, wiring, and most any of the electrical devices. In fact, the national safety records indicate that dirt itself and contamination is responsible for a large percentage of industrial accidents. Elimination of dirt, properly maintaining the air systems along with good housekeeping, will not only prolong the life of the apparatus but it will, also, reduce the accident rate and human misery associated with such unfortunate circumstances.

There are acceptable commercial fluids on the market which can be used for cleaning electric motor and generator windings to remove, in most cases, the damaging dirt, grease, oil and contaminations which inherently collect on these parts. The old practice of using carbon tetrachloride should be discontinued due to the health hazard associated with its use. Compressed air, if properly dried and cleaned, can be used for removing free dirt from many parts of motors, generators, switching equipment and machinery in general. However, the use of compressed air should only be tolerated when in the hands of an entirely competent person particularly around electrical machinery since considerable damage can be done by its incorrect application.

One of the greatest problems in the mills today is the ability to supply sufficient quantities of clean, free air for ventilation and cooling of equipment.

It is recognized that certain sections of a steel mill inherently operate at a relatively high temperature and the equipments in these locations are usually designed to give satisfactory performance in such temperature conditions. In the case of electrical machinery, it is generally recognized that excessive heat is the natural enemy of most electrical insulations. It, also, becomes a problem on machines designed with close tolerances, where undue expansions are caused by higher temperatures. In many cases, mechanical parts fail due to excessive temperatures. Electrical machinery will give more years of service if it is operated within its temperature rating. Obviously, if it is operated at temperatures in excess of that for which it is designed, the total expected life of the machinery itself will be reduced. Temperatures can be controlled by following the ordinary precautions of proper application, ample ventilation, or the installation of surface coolers or refrigeration wherever necessary. In fact, the operating temperatures of machinery along with the atmospheric

conditions will dictate the inspection and repair schedules that should be followed on these installations.

Overheating of electrical motor and generator coils increase the rate of deterioration of the insulating materials. This deterioration can be detected by close inspection and tests and will show up as cracks in the insulation, loose coils in the slot, loose coil wedges and a general dryness and brittleness which will only lead to an early failure of the electrical winding.

The third item of equipment maintenance is the actual down-to-earth manual labor element of doing those things that must be done in order to keep the equipment producing at its highest level. Most machine failures give ample warning of impending trouble if the signal is picked up and duly recognized. Usually small troubles and natural wear are the beginning of major outages. For the want of minor attention and repair work, many mill equipments have carried on into complete destruction of a major motor, generator or roll-stand itself. In too many cases, a production outage has been forced upon the mill due to the need of replacing a carbon brush, an oil ring, or bearings, or, perhaps, even greasing a coupling at the proper time.

In too many cases, the path of least resistance is taken and the small jobs are put off for a more opportune time, for a time when it will not interfere with the chores at hand or, perhaps, at a time when another shift might be required to take care of it. This type of maintenance surely is not productive maintenance and will invariably result in major unplanned and uncontrollable outages that will result in costly production losses.

With rigid inspection and a reasonable amount of maintenance attention, as well as the replacement of worn parts, immediate production outages will be definately reduced.

The real benefits of a productive maintenance program will be achieved when minor troubles are taken care of immediately, and major failures are detected before they occur, and put on a definitely planned and scheduled basis to be performed at a time that it will create a minimum disturbance and cost to the overall mill production.

In maintaining electrical machinery, it is necessary to carry on a continuous program of inspection of the condition of the electrical equipment. The important items to look for are the load conditions, temperature conditions and cleanliness. Very frequently, impending mill trouble can be detected by instrumentation.

The inspection of large motor and generator windings should be carried on regularly. Windings should be inspected for looseness in the slots, puffed coils, loose tie bands, cracks or deterioration, and on the higher voltage machines, for the effect of the presence of corona.

Insulation resistance tests should be taken at intervals and properly recorded on the maintenance record cards. This data alone can foreshadow impending trouble and point the way for a planned outage and the necessary repairs. The insulation resistance test will indicate the presence of dirt or moisture and, in many cases, it will be necessary to thoroughly clean and dry electrical windings before applying an insulation test. The insulation tests do not always prove that the winding is safe for continued operation. However, it does give an indication of the general condition, and will indicate the trend of the insulation level if repeated readings are taken over a long period of time. A routine high potential test is the only method of giving reasonable assurance that electrical windings are satisfactory for continued use. Many maintenance operators have avoided high potential tests for fear that the insulation would be broken down. However, the realistic viewpoint would be that if the winding insulation were at that low level, the windings should be replaced.

It is difficult to arrive at a fixed value for routine high potential tests due to the size and design of the different equipments located in the average mill. However, a suggested value of 120 per cent of line to line voltage plus 400 volts will give a reasonable assurance that the machine may be returned to service. This value may be increased by 10 per cent for large machines wound with class B insulation.

The importance of the installation dictates the advisability of carrying renewal parts such as bearings, brushes, armature coils, couplings and other parts that might be needed for immediate maintenance work.

One very important ingredient of a successful productive maintenance program is that of human relations. No program or plan will work successfully without a good human relations program. Employees must be properly trained and instructed in carrying on their duties. It is just as important that the manpower is properly applied to the job as it is that the correct motor is driving the mill. Good maintenance men like their job.

The biggest task before management today is to win back the full confidence of their employees who are the all important segment of the total mill investment. Management must establish in their minds a feeling of peace, security, and respect for the very jobs on which they are working and for the company with which they are associated. This task is made doubly hard by the false prophets who have had a field day in peddling dissention, unrest, fear, hatred and bias in the very area where management has feared to work and failed miserably. Your maintenance men in particular must know that they are a vital part of the total organization.

The trend of modern machine design is to build the skill and precision into the machine and remove the responsibility of precise operation from the operator. This type of machine design naturally makes machinery, electrical control, and all of the devices far more complicated than ever before and, obviously, the burden of successful operation and full production is removed from the operator and is placed on the maintenance department. It is felt that the human relations element of the maintenance department will determine largely the success or failure of a productive maintenance program. If an aggressive and honorable human relations program is established and a productive maintenance program inaugurated, one can be assured that maintenance costs will go down while production per manhour actually will increase.

TRANSFORMER MAINTENANCE

By B. L. BRITT
Electrical Service Dept.
Wagner Electric Corp.
St. Louis, Mo.

. . . . transformers require relatively little maintenance . . . . when maintenance is required, it pays to be well prepared . . . .

▲ MOST transformers have been very heavily loaded for the past twelve years, and in many cases their continued good operation has been merely taken for granted. Also, because they have no major moving parts, they are frequently not included in preventive maintenance schedules. Consequently, there are a few failures, other than accidental, which occur at the most awkward times, and which necessitate emergency measures at the usual excessive costs.

Further, all too frequently, spare parts are not available at the plant site. Such parts as one set of high voltage bushings and one set of low voltage bushings, one complete set of gaskets, gasket cement if required, oil gages, thermometers and similar accessories per design of transformer may be worth many times their cost if by having them in your plant, you can reduce the "down" time of a transformer. Lack of preparedness in this respect is due in some cases to inexperience on the part of the purchaser of the equipment in question, or in some cases is due to some temerity on the part of the sales engineer who feels that it might be embarrasing to suggest to the customer that he might need some spare parts at some future time, which actually is doing the purchaser of the transformer a disfavor. In other words, the stocking of essential spare parts may be likened to a form of insurance for continued operation.

A well-designed transformer which has been properly installed, is periodically inspected and properly maintained, may be expected to satisfactorily operate for years, barring accidents.

A definite schedule of intelligent transformer inspections should be established.

Under ordinary operating conditions, a transformer inspection should be made every six months. This periodic inspection should, of course, include assurance that all electrical connections are tight and in good condition. A loose connection at the terminal board of a 6000-kva furnace transformer so badly carbonized the oil that the dielectric dropped to 20 kv which necessitated cleaning the core and coil assembly and filter-

Figure 1 — Interior of transformer field service truck shows air pressure and vacuum gages and valves, and front ends of the two 250-gal tanks.

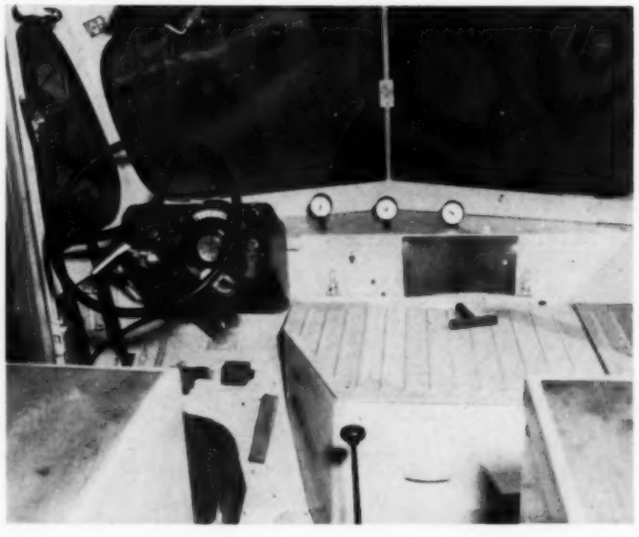


Figure 2 — Interior of transformer field service truck shows welding generator, 250-gal tank and workbench, hot stick cabinet, filter paper drying oven, part of filter press, CO_2 extinguishers, etc.

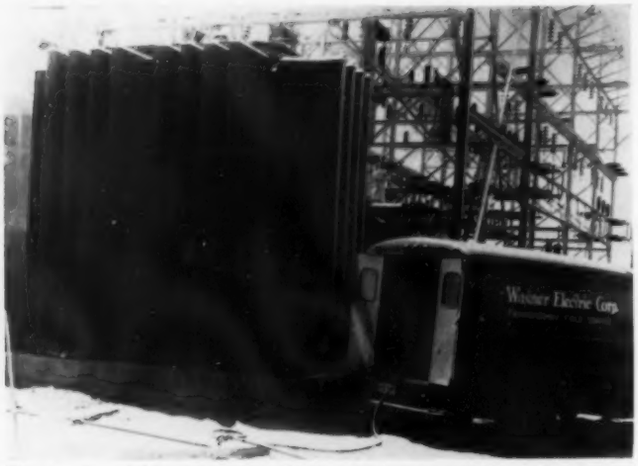


Figure 3 — Transformer field service truck is being used to pull vacuum while oil filling a new power transformer.

ing the oil which required a shut down of approximately 40 hours. The loss of a good ground connection to the transformer tank might mean that in addition to endangering personnel, and incidentally, as much as 1300 volts from tank to ground has been measured on a transformer which had no electrical defects, you might not have the full extent of the protection afforded by the special arcing gaps or the coordinated insulation of the bushings to ground. The bushings, of course, must be kept clean from any conductive coatings. The

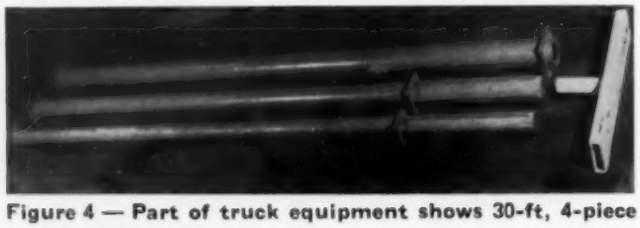


Figure 4 — Part of truck equipment shows 30-ft, 4-piece steel gin pole.

cleaning of the bushings has in some cases been improved by the use of some of the new silicone type coatings which make it easier to remove foreign matter from the porcelains.

Probably the greatest enemies of transformers are heat and moisture. The loads should be well balanced per phase, and within ASA loading standards. Records should be kept of the transformer loads and temperatures including the ambient temperature so that the temperature rise may be correctly recorded.

OIL FILLED TRANSFORMERS

In the case of oil-filled transformers, a dielectric test should be made on the oil, and it is considered good practice to have a minimum of 26-kv oil. Should the dielectric drop as low as 22-kv, it is highly recommended that the oil be filtered until it has a minimum value of 26-kv. While filtering, the transformer should be deenergized because of the likelihood of aerating the transformer oil in the filtering process which would, of course, weaken the dielectric values of the transformer even though the dielectric of the oil was at a satisfactory value. After the oil dielectric has been raised to a suitable value, it is desirable to apply vacuum on the transformer, provided the transformer is structurally designed for vacuum, before energizing it to remove any air which may have been introduced into the oil. This process is particularly recommended for all transformers, 501-kva and above of the 69-kv insulation class and higher, and for all 10,000-kva transformers and above regardless of voltage class.

If the transformer tank structure is not designed for full vacuum, it is then recommended that the transformer be energized at a reduced voltage for several hours which will assist in removing the air from the oil. Under no circumstances should a vacuum be pulled on any transformer which is energized. The reason for this, of course, is that if the transformer is energized and a vacuum is applied, any air bubbles will drastically increase in size which may mean that where an air bubble occurs there will not be sufficient oil to provide adequate insulation.

Many transformers, even of the higher voltages, have had the oil filtered or have been filled with oil without benefit of the vacuum process, and have been put on the line with apparent success. Most of these transformers are perfectly safe at their normal operating voltages, but may not be sufficiently insulated to withstand surge conditions.

As an illustration of the amount of air which may be trapped in a transformer element and in the oil, a 5-kva transformer was filled with oil to the proper level then vacuum applied. It was then noted that the oil level had dropped approximately $\frac{3}{8}$ in.

During the periodic inspection, acidity tests should be made on the oil. The recommended maximum of oil acidity should not exceed a neutralization number of Mg KOH per gram of oil of 0.50 maximum.

Should the acidity be above Mg KOH per gram of oil of 0.50, it is recommended that this high acid oil be removed from the transformer; that the transformer be flushed with new, dry transformer oil, and when it has been thoroughly cleaned, the transformer be filled with new oil.

There are several methods of preserving the quality of transformer oil, such as the use of sealed tanks, or expansion tanks of either the single or double chamber

Figure 5 — Exterior view of transformer field service truck shows front mounted winch and, just below windshields, the air and vacuum jacks or connections.

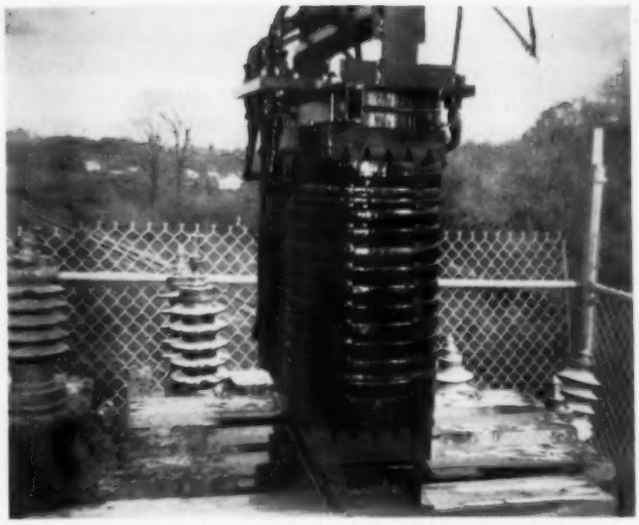


Figure 6 — Organic varnish compound impregnated transformer has had normal loading.

type; the use of inhibitors; inert gas systems or activated alumina thermo siphons.

Some of the older design transformers have had improvements made in the field with good success by better sealing of the tank and cover, by the addition of single or double chamber expansion tanks, inert gas equipment, activated alumina thermo siphons or inhibitors.

Megger tests should be made between each of the windings and between each winding to ground and recorded as well as the temperature at which they were taken. Over the years, inspection of all these records may be made which will give a good indication of the condition of the transformer. Should it be necessary to drain the oil from a transformer, much time may be saved by nitrogen filling the transformer as the oil is removed, as this will eliminate the possibility of the transformer absorbing moisture. Should it be necessary for a man to enter the transformer to perform inspection work, he should, of course, use an oxygen mask or one of the "snorkel" type breathing apparatus. This is felt to be better practice than removing the oil and thoroughly ventilating the tank which may permit introducing moisture into the transformer. At the periodic inspection, transformers equipped with a pressure vacuum gage, readings of this should also be recorded. If it is equipped with inert gas equipment, this also should be carefully gone over to be sure that all joints are tight and everything is in good working order. The remaining contents of the nitrogen bottle should be recorded, and the pressure should actually be increased on the nitrogen control to observe whether or not the pressure relief on the nitrogen control is in good operating condition. Any auxiliary fan or blower, or any other heat exchange equipment, should be manually operated to assure that it is in good operating condition. Most auxiliary fan and blower motors are grease lubricated, and the manufacturer's recommendations should be followed in regard to inspection and lubrication of these auxiliaries. Any switch gear or tap changing equipment should be inspected to make sure it is in good operating condition and contacts are clean and in good condition. Inspection should be made for any leaks, and any offending gaskets should be tightened or replaced. Any pin hole leaks should be peened shut or arc welded should the leak be beyond the possibility of peening. Should any oil sludging be noted, examination should be made to determine the cause, such as excessive heating or oxidation of oil. On some of the older design transformers, the windings may have been impregnated with organic varnish or compound. Most of these older designs were probably equipped with open type breathers. Occasionally in these organic varnish impregnated transformers, there has been a blooming of this varnish, and this has been evidenced by extrusions or lumps of varnish appearing on the surface of the windings. These blooms or extrusions of varnish, when removed and tested, were found to be as excellent dielectrically as when the varnish was new. This phenomenon apparently has little if any effect on the operation of the transformer. If a transformer shows evidence of this blooming effect and it is untanked, the usual practice is to employ a stiff fibre bristle brush and scrub the blooms from the coils and re-install the core and coil assembly in the transformer tank. This operation does not take very much time, and if it is done under good, dry weather conditions, drying out of the core and coil assembly is rarely necessary.

ASKAREL FILLED TRANSFORMERS

The same periodic inspection schedule should be made for askarel filled transformers in regard to tightness of electrical connections, ground connections, observation of leaks, etc. Askarel transformers, of course, are built only in the sealed construction to prevent exposure of the liquid to atmosphere. A dielectric test should be made to determine if there is any moisture in the liquid. The sample should be taken from the top of the liquid as askarel is heavier than water. Therefore, water and many of the impurities are found on the top of the liquid rather than at the bottom as is the case of oil filled transformers. Likewise in filtering askarel liquid, the suction side of the filter press is put on the upper filter press connection of the transformer and the pressure side of the filter press should be discharged into the bottom of the transformer.

Extreme caution must be exercised in handling askarel and metal filter press hoses should be used rather than any of the known synthetic rubber hoses such as may be used with transformer oil. It should be stated at this point that the selection of gaskets, gasket cement and insulating materials is very critical, and in all cases, only those materials recommended by the manufacturer of the transformer should be used. Failure to follow the manufacturer's recommendations may result in a total loss of the askarel and possibly the transformer.

We have seen cases where improper gaskets or other materials used in askarel filled transformers, not only ruined the askarel liquid beyond repair, but caused it to leak through and irreparably damage cables and associated gear.

DRY TYPE TRANSFORMERS

Dry type transformers are generally made 15-kv class and below. They are usually of the open type con-

Figure 7 — Organic varnish compound impregnated transformer has been heavily overloaded.

struction, but some of them are also being made of the sealed inert gas filled construction. These transformers should also be inspected periodically, care being taken to insure that all electrical connections are tight and megger readings and temperatures recorded. Dry type transformers, of open type construction are cooled by the surrounding atmosphere and are, therefore, adversely affected by dirty or moist air. They must be kept dry and free of accumulation of dust and other foreign matter. They should be protected with arrestors of the type similar to those used to protect a-c rotating machines rather than the type used to protect Liquid Filled Transformers.

It must also be remembered that dry type transformers which are not energized, if not kept at least as warm as the surrounding atmosphere, are subject to condensation, and it may be necessary to dry them out before energizing them. In some cases this might mean that a spare transformer which is not kept above normal temperature by external means such as strip heaters or infra-red lamps or floated on the line, may not actually be considered as a spare transformer ready for immediate use. There are cases where dry type transformers have had heating elements put in them to keep them dry for immediate use. However, it is usually as economical to float them on the line as to operate the auxiliary heaters.

In summing up transformer maintenance and in effecting repairs to transformers even to the point of installing complete new windings, it is frequently quicker and more economical to perform these repairs at the job site than to spend the time and expense involved in removing the transformer from its location, loading it, and transporting it to and from a service shop and re-installing it. This, however, calls for good coordination between the owner of the transformer and the people performing the work or supplying the necessary materials for the work. With this in mind, a transformer field service truck has been designed and used with considerable success for the past two and one half years. This truck enables all of the necessary equipment and tools to be brought directly to the job site. The truck is fully enclosed and heated to permit operation in all kinds of weather. It is equipped with a winch; a 30-ft telescoping gin pole; necessary blocks and tackle; hydraulic jacks of 120-ton capacity; filter press and associate equipment which is adaptable for either oil or askarel; vacuum pump; air compressor; arc welder; 60-cycle generator for its own independent power supply; 500 gallons of tank capacity; hot sticks; high voltage detector sticks; ground clamp and cables; rubber gloves; blankets; weather-proof tarpaulins. It also has an oil dielectric testing transformer; an acidity tester; megger and other electrical testing equipment; a black light leak detector; all of the necessary small hand tools, etc., for working on transformers. Modifications of this truck and its equipment are being used by a number of the utilities for assistance in work on transformers and associated gear.

DISCUSSION

PRESENTED BY

JAMES H. FRANZ, Superintendent Operating Maintenance, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.

B. L. BRITT, Manager, Electrical Service Dept., Wagner Electric Corp., St. Louis, Mo.

A. J. BECKER, Pittsburgh Works Sales Service, Transformer Dept., Allis-Chalmers Manufacturing Co., Pittsburgh, Pa.

RICHARD TAYLOR, Foreman, Sub Station and Tests, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.

GEORGE TIPPINS, Manager, Tippins Machinery Co., Pittsburgh, Pa.

JAMES D. O'ROARK, Assistant Manager, Service and Maintenance, Weirton Steel Co., Weirton, W. Va.

CARL J. DEGENHARDT, Assistant Division Superintendent of Maintenance, Homestead Works, United States Steel Corp., Munhall, Pa.

James H. Franz: The silicone that was mentioned, is that a paint or a wax?

B. L. Britt: The one I have seen is a liquid preparation and I do not know whether you would call it a paint or a wax.

James H. Franz: Is it put on and buffed later?

B. L. Britt: No, the bushings are cleaned and then it is painted on, as I have seen it. You can put it on with a sponge, a rag, brush, dip or spray.

James H. Franz: In your purifying methods, do you

have any personal preference, such as fuller's earth versus the blotter? There is the vacuum type purifier too.

B. L. Britt: No, we have standardized on the straight blotter filter press.

James H. Franz: You also mentioned activated alumina. The acidity of the oil is apparently used as the basis of judgment. They feel if they keep that low enough they do not get sludging.

B. L. Britt: That has worked out very well in some places.

James H. Franz: Do you recommend its use?

B. L. Britt: We have used it. We have a number of people who are using it.

A. J. Becker: In the early part of the paper you recommended a spare set of gaskets, among other things. You also recommended, as a second point, that the transformer be inspected every six months.

B. L. Britt: Yes.

A. J. Becker: Can you elaborate on that? Do you mean internal inspection? Do you mean external inspection? Also, in reference to the gasket, do you recommend a spare set of gaskets? Because, after a year or two laying around in storerooms, they get hard and brittle and they are practically useless, and you have to order over again.

B. L. Britt: First I will touch on the gaskets. If you are talking about most cork gaskets, they do dry out. Most of the gaskets in use today are corprene, which seem to stand up much better. Now on long-time storage—and that is what I believe you are bringing up—those are sometimes packed in tin cans which have been evacuated and soldered shut, the same as some people keep electric motor coils in long-time storage.

On six months' inspection by all means you should have an oil test, both dielectric and acidity. Observation should be made for sludging. The external connections should be gone over if at all possible. It is not always possible to have an outage and do that.

On the internal inspection, that may not be required every six months. You will have to get that from your own experience.

A. J. Becker: Do you have any recommended value for megohms resistance per thousand volt operating voltage on an askarel filled job?

B. L. Britt: On an askarel filled job (talking of winding insulation resistance), yes. Ordinarily you will find that it runs lower than on oil-filled transformers. On the transformers I have encountered, a shell type job, oil filled, you may get lower megohm readings, than a core type job.

A. J. Becker: Do you have any values on the askarel filled?

B. L. Britt: I would say it runs from 200 to 300 from high voltage to lower voltage.

A. J. Becker: Is that per 1000 volts?

B. L. Britt: Askarel transformers are low voltage compared to oil filled. In other words, you go about a maximum of 23,000 on askarel filled transformers. If you go to 33,000 you have to insulate them for 41,000. In other words, go up another insulation grade. We would expect to have 200 to 300 megohms high voltage to ground, or high voltage to low voltage, on any askarel filled transformer, and about 50 megohms low voltage to ground on any askarel filled transformer. Whereas, on oil filled, you expect a thousand megohms plus.

Richard Taylor: Under any conditions would you recommend filtering the liquid in an energized transformer?

B. L. Britt: No. You are going to get air in it when you filter

George Tippins: What is the best way to clean the sludge on a transformer, a tank? Do you use gasoline?

B. L. Britt: No, sir. We use new transformer oil. On an ordinary power transformer, we will put about a barrel of oil in the transformer and just circulate, take the cover off, and get in with a hose.

George Tippins: What if you take the whole core out?

B. L. Britt: You do not have to ordinarily, unless it is a horrible job.

George Tippins: Some of them may have a cake of five or six inches.

B. L. Britt: That is another thing. If you have an actual cake, the quickest thing to do is to untank it.

George Tippins: How do you get it out?

B. L. Britt: Get in with a shovel, or anything else you can.

George Tippins: Should you use oil.

B. L. Britt: Get the cake out first. Then wash with transformer oil.

James D. O'Roark: I would like your comments on the possibility of rebuilding an oil filled transformer over into an askarel filled type.

B. L. Britt: On an oil-filled transformer, (assuming that the windings are not scrap), you just want to make it non-inflammable. In the first place, many oil-filled transformers have a varnish-filled cambric tape in them. If you want to make a mess, put askarel in with varnish-filled cambric tape. It just turns the askarel black. That is one thing. Another is if the inside of the transformer is painted, the askarel would take the paint off. You would have to sandblast the whole inside of the tank, put in all new gaskets, and make sure there is no varnish cambric, or material of that nature in there.

Carl J. Degenhardt: What is the best temperature that you recommend to keep the oil at, while you are filtering?

B. L. Britt: We have never accepted or tried to build up a standard of heating the oil to any particular temperature. Now, you can heat the oil and the oil may pick up more moisture from the windings, but you can not get the moisture out of the oil. So you have to let it cool back down to get rid of the moisture. I am thinking now of a blotter press. With a centrifuge you take a great quantity of moisture out, but for the final drying you use a filter press. So we just try to work with it at whatever temperature the transformer happens to be. If you are drying, then we will put impedance voltage on the transformer and get it up to full load temperature, and filter. You may not get as good an oil test from the sample taken with that hot oil as if you let it come back down to room temperature.

Carl J. Degenhardt: We have experienced trouble getting the moisture out of the oil as you have explained when the oil temperature is heated too high.

FIELD REPAIR OF Large Rotating Machinery

By M. J. WOHLGEMUTH
Manager Electric Service
Westinghouse Electric Corp.
East Pittsburgh, Pa.

. . . . it is possible to repair heavy equipment and get factory-built quality . . . .

▲ KEEPING electrical equipment in proper condition so that maximum production requirements can be met, is one of the important functions of the electrical departments of our steel plants. Preventive maintenance has been widely talked and discussed, and many of our steel plants are doing an excellent job along these lines. Some manufacturers of electrical equipment have regular maintenance inspection programs for certain types of equipment, but in general, the plant electrical department must bear the brunt of such inspections with the help, as required, from the manufacturers of the equipment.

In spite of all the preventive maintenance that can be applied, a large main drive equipment will develop trouble. It may be a grounded coil in the stator of an a-c motor or in the armature of a d-c motor, but when it happens on large equipment, a shut-down is the result and this, of course, means every effort must be made to locate and repair the defect with the least outage time.

In the case of large equipment, it is usually not feasible to take the equipment out of the mill to a repair shop, due to the time factor involved in complete dismantling and transporting to the repair location. In many cases, it is a major job to try to get a large armature or stator out of the mill due to building and other restrictions. In some instances, it might be necessary to take out a portion of the building or dismantle other machines, either partially or entirely, in order to get a large piece of equipment out of its location.

The only solution, then, is to make the necessary repairs in place. In the case of a d-c armature, the frame can be split and the top half taken off, so that the armature can be worked on. On an a-c rotor or stator, the machine in most cases is provided with stator shift so that the rotor can be uncovered to work on either stator or rotor. Where stator shift is not available, the machine must be dismantled to enable the rotor to be removed and placed on a built-up skid to facilitate work.

Usually, the plant does not have sufficient trained personnel to tackle repair of a large rotating machine, and it then becomes necessary to call on the builder of the equipment to handle the job. The manufacturer has, at the call of the district organization, trained personnel in the form of winders, mechanics, bladers, engineers, together with access to materials necessary to do the job, so that if trouble does occur, prompt action can be taken to organize the crew necessary for the particular job.

These repair jobs done in the field use the same

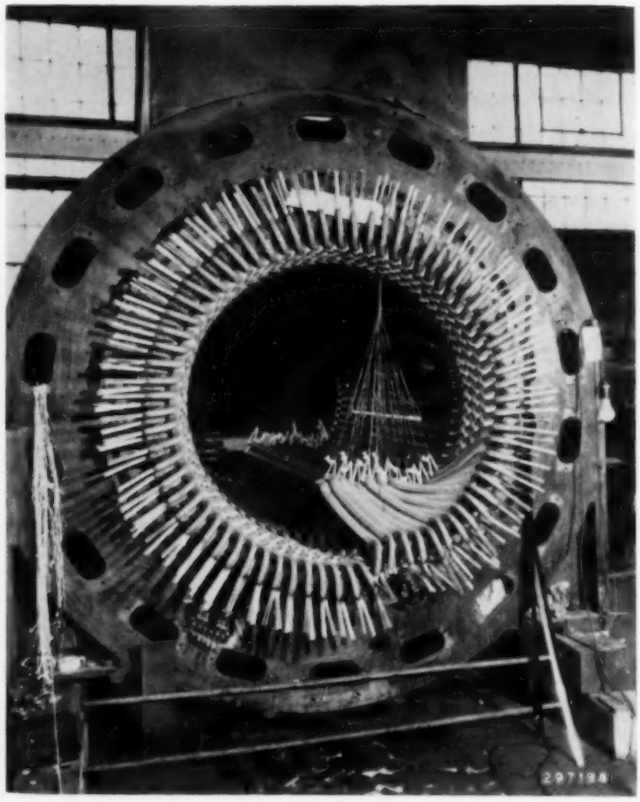


Figure 2 — One way of holding the throw on large a-c stators is illustrated here.

Figure 1 — View shows one proper method of blocking and tying coils on large a-c stators.

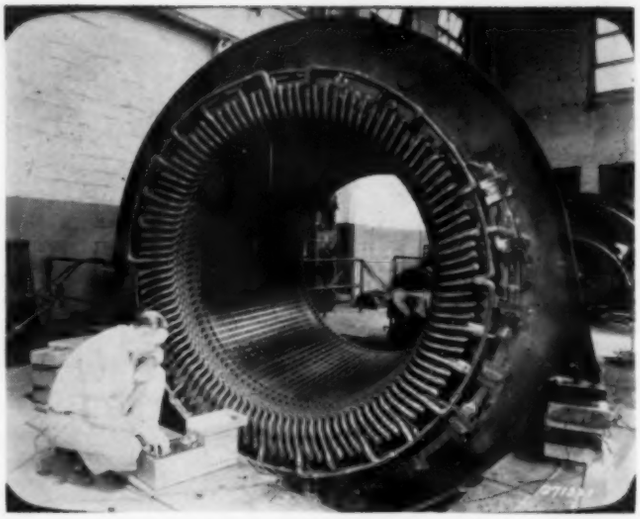


Figure 3 — Insulation resistance is checked before returning unit to operation.

materials as are used in the factory, and also factory methods of repair and testing. In many cases, in repair of older equipment, modern materials are often and usually used in the place of outmoded materials or processes. In other words, repairs to large equipment in the field attempt to bring the equipment to a state better than it was, or at least as good. Of course, when making partial repairs or "patching," as it is sometimes called, the condition of the equipment after repair is, of course, only as good as the weakest point of the old parts undisturbed during the repair. In such cases, we would, of course, clean and revarnish equipment to endeavor to make the unit as good as is possible.

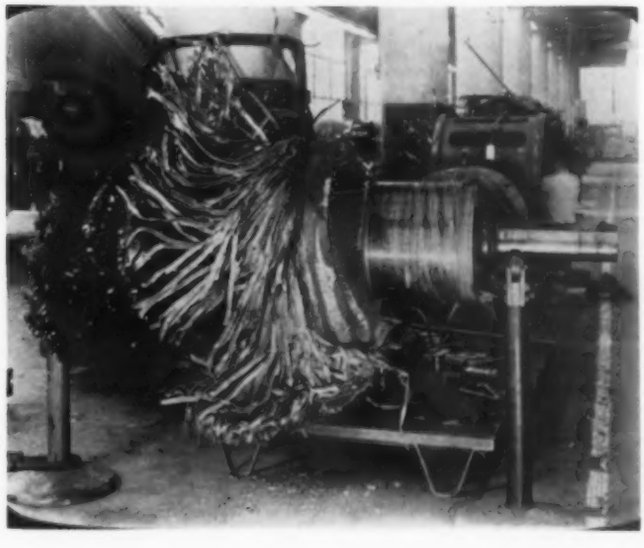
Some problems arise in making repairs to rotating members in the field, such as d-c armatures or rotors of large wound rotor motors. In the event of a rewind or replacement of one or more coils, it is necessary to reband the rotor or armature. There have been a number of ingenious methods used to turn the rotor or armature so that proper banding can be done. At times, a belt has been used around the rotor body and several means of driving used, such as a gearmotor or airmotor. Another method is to use a split sprocket clamped on the shaft and a chain drive to a gearmotor. Each job usually presents new problems so that the engineer in charge must be rather ingenious to cope with situations as they arise.

Figure 4 — End turns and connections must also be carefully checked.

Figure 5 — Coils are being installed in stators of synchronous machine.

In making connections, especially in a-c machines, brazing, using low voltage high current, is generally used. Special brazing transformers and tongs are available to do practically any kind of connection work. Connections from d-c armature coils to commutator risers are brazed where possible. When brazing cannot be used, it is necessary to resort to hand soldering. This

Figure 6 — Even though this machine is in extremely bad shape, it can be restored to service.



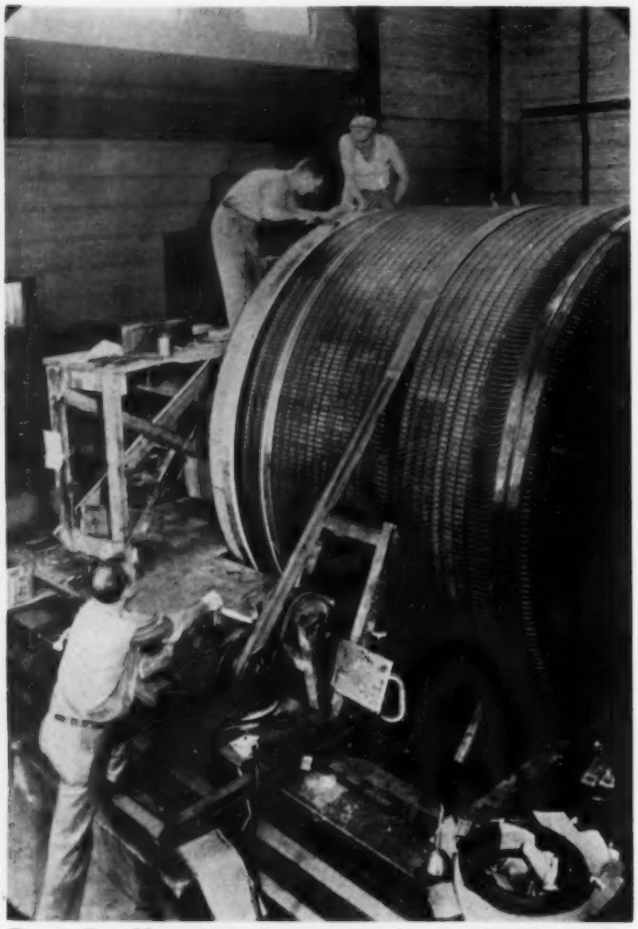


Figure 7 — Many ingenious set-ups for rotating the equipment have been devised.

presents problems, as soldering at best is a tough job and requires extra skilled personnel with plenty of patience in order to do an A-1 job. Soldering is one part of a job which cannot be rushed. It is extremely better to take a little longer time and have the job stay put after reassembly and starting, than to rush and take shortcuts which usually result in doing some of the job again.

The repair of high voltage rotating equipment presents additional problems. Fortunately, not too many of our steel plants have equipment rated at 11-kv or 13.8-kv. Equipment in this class would be large induction or synchronous motors and turbine generators. Repair of such equipment necessitates the use of extra skilled people and special tools and test equipment.

In general, field repairs can be accomplished expeditiously by proper planning and the use of qualified personnel and supervision, together with the correct materials for the job.

DISCUSSION

PRESENTED BY

ERIC L. ANDERSON, Superintendent, Electrical Dept., Bethlehem Steel Co., Johnstown, Pa.

Eric L. Anderson: I would like to comment briefly on our experience with periodic checking of main drive equipment to minimize failures. About two years ago a new blooming mill was put in operation at the

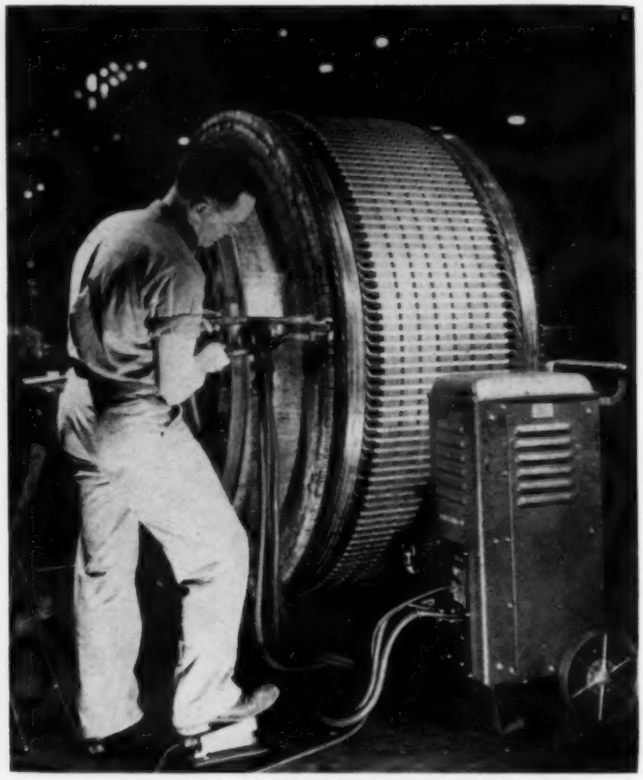


Figure 8 — Constant checking of all details is necessary in the rehabilitation of this equipment.

Johnstown plant, and in order to maintain operations, it was necessary to operate the main drive equipment for a period without the ventilating system and in the same room with a steam-driven mill. It is readily seen that such a situation exposed the new electrical equipment to a considerable amount of dampness and dirt.

After the motor room was completed and the ventilating system put in operation, a setup was made to take megger readings on the various parts of the equipment. Some parts are checked once a year, others every six months, some every month and the main motors and generators are checked weekly.

During the periodic checks on the main drive motors, one of the motors showed a consistent dropping off of resistance value. Investigation disclosed that one of the oil lines to the bearings had sprung a leak. Some of the oil was being sucked into the armature windings. It was possible to clean this off and bring the megger readings back to normal.

In another case, a very rapid drop in resistance values was indicated on the main drive generators. Investigation of the cause of this drop in resistance showed that the main circuit breakers were located so that part of the air stream from the generators passed over them. The brush dust carried from the generators impinged on the d-c circuit breakers and coated the plastic insulating bushings on the pins with a conductive coating. The breakers were taken apart and cleaned and the megger readings brought back to original value.

I am satisfied that the use of periodic resistance tests on main drive equipment is desirable and certainly our experience has shown its value. Undoubtedly, had readings not been taken, we would have been faced with the failure of major equipment resulting in costly repairs and bad mill delays.

Rebuilding Steel Mill Rolls

By ROBERT HALL

Field Engineer, The Lincoln Electric Co., Cleveland, Ohio

. . . . roll life is extended by the welding practice here described . . . .

▲ BELIEF that many rolls heretofore scrapped could be salvaged by arc welding has led the Wheeling Steel Corp., Wheeling, W. Va., to install equipment for this purpose. Although in use only a few months, this installation has demonstrated its ability to rebuild many rolls at much less than replacement cost.

Moreover, the rebuilt rolls yield at least equal performance, as compared with new rolls, and in most cases have shown a lower rate of wear, resulting in marked increase in useful life. Repeated rebuilding can be done, and it is already evident that the automatic arc welding process employed will definitely reduce new roll purchases.

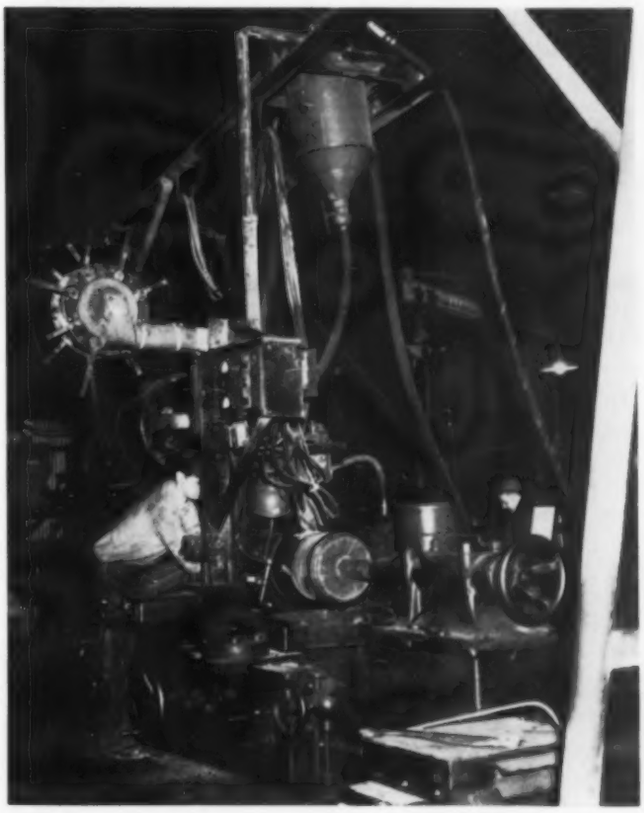
Only a small investment in equipment for rebuilding rolls has been required and its cost will be quickly amortized out of the savings attained. Actually, the total cost is modest as the chief items of equipment required are a standard automatic head for hidden arc welding, supplied with current from two 600-amp generators having the usual control equipment and an old engine lathe, Figure 1, modified to drive the roll and advance the welding head as the required weld beads are laid down.

An operator constitutes the labor force needed for welding. Only on occasion is assistance required. Subsequently, the rolls usually require machining, but this is done on a lathe that is needed anyway for repairing damaged roll surfaces.

Much of the work done to date has been on pipe straightening rolls. Three such appear in Figure 2, one before rebuilding, one after weld build-up and one after the welded surface has been machined. Hardness of the new surface can be varied to suit conditions, but about 37 Rc hardness (equal to about 49 Scleroscope) has been found satisfactory and is readily attained. Other rolls rebuilt to date include furnace pinch rolls for feeding skelp mills, skelp mill rolls, feed rolls for tube mills and edging rolls. Worn crane wheels and brake drums for cranes also have been built up and refinished at a cost far below replacement costs. Weld beads are uniformly high in quality, and possess the requisite hardness and toughness to resist wear and whatever shock may be involved in service.

To lay down a continuous weld bead around a roll, it must be rotated at a suitable surface speed for welding. At the same time, the head must be advanced longitudinally at such a speed that the bead in one revolution is close to and fuses with that laid down in the prior revolution as well as with the metal below the bead. If the surface required is a true cylinder, no radial feed is necessary during the build-up, but if the surface is necked or beveled, a radial feed is needed to keep a constant arc gap. Such a gap is normally maintained by the automatic wire feed of the head but considerable variations require that the head be adjusted radially.

Figure 1 — Lathe is modified for use as an automatic welding machine for roll build-up. The welding head, controls and reel are mounted on a column bolted to the carriage which is moved longitudinally by a lead screw.



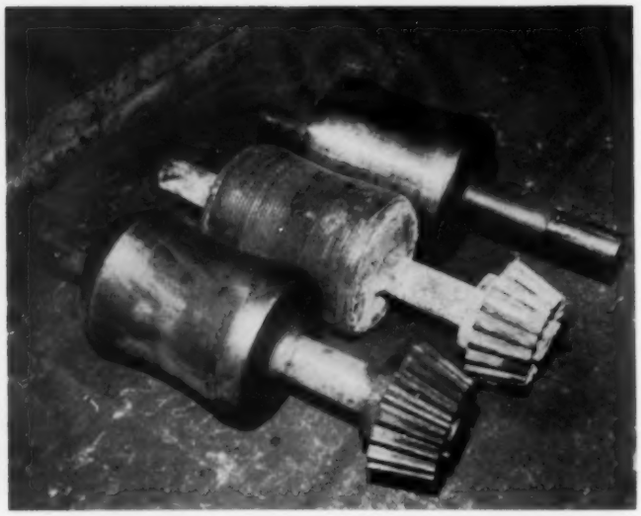


Figure 2 — Pipe straightening rolls are shown as they appear when worn (foreground), after build-up by automatic arc welding (center) and after the built up roll has been machined (background) at the Wheeling Steel Corp. plant.

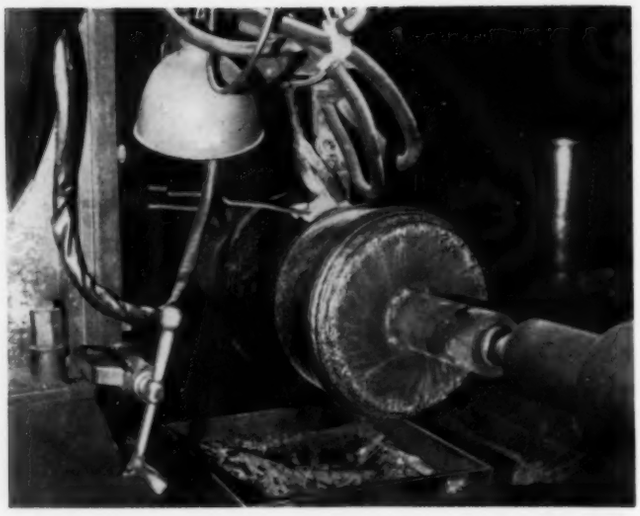


Figure 3 — Close-up shows roll in process of being built up by automatic arc welding. At left is the hand crank that turns a screw to adjust the welding head vertically. Flux is fed through a forked tube to cover the arc.

All of these conditions are met by the lathe set-up shown in Figure 1 and shown more closely in Figures 3 and 4. For rotation, the roller is set on normal lathe centers and is driven by a dog or dogs on the faceplate as Figure 4, indicates. Brushes, appearing at upper right in Figure 4 bear on the outside diameter of the faceplate and are connected to ground so that the roll itself will be grounded. Gears in the headstock are so set as to provide the desired surface speed for welding, usually about 40 in. a minute.

To control motions of the welding head, it is supported on a column bolted to the lathe carriage crosslide. Longitudinal motion of the carriage, and so of the head, is controlled by the lead screw exactly as if turning or thread cutting, one lead being set to suit the size of the bead laid down.

Position of the head supported by the column is such that the electrode wire projects downward vertically above the roll and about 1¼ in. in front of center — that is, nearer the operator than a vertical plane through the roll axis. To adjust the head vertically, it is mounted on a column slide that is moved up and down by a vertical screw turning in bearings on a column. A bevel gear at the bottom of the screw meshes with one on a horizontal shaft carrying a hand crank as shown in Figure 3. This crank is used to raise and lower the head as required to follow the contour of the roll.

When there is a bevel to be built up as at the end of the roll in Figure 3, the head crank is moved in combination with the longitudinal feed of the carriage so that the electrode follows this bevel. In building up cylindrical surfaces, however, the vertical feed is set properly at the start and need not be touched until the bead layer is completed. Rotation of the roll while making a weld is always clockwise (when viewed from the tailstock end as in Figure 3) so that unfused flux drops down back of the roll as shown in Figure 4.

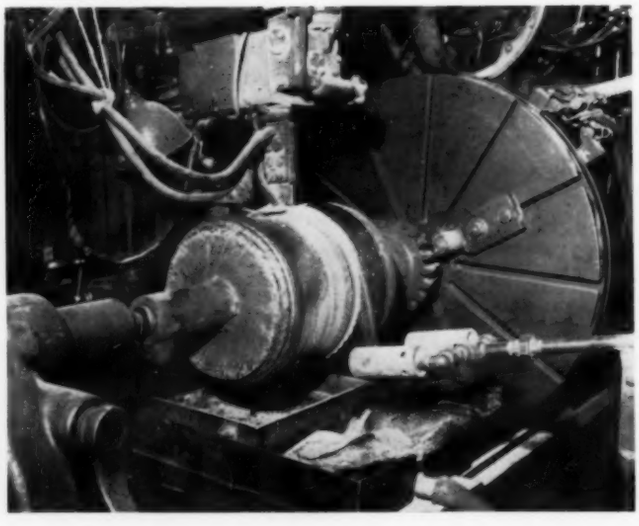
Besides the automatic head which includes the usual small flux hopper, the column supports the control panel and a reel from which the wire is drawn automatically as welding proceeds. All of these components move as the carriage is traversed longitudinally, always leaving the control panel close to the operator.

To keep the arc covered, granular flux is fed automatically from the small head hopper whenever the arc is on. To keep this hopper filled, it is connected by a flexible tube to a large vacuum filled hopper on a carriage that rolls along an elevated track parallel to, but well above, the bed of the lathe.

Some of the flux covering the arc is fused and adheres loosely to the roll, but is easily chipped off by the operator or drops off after it cools. Unfused flux falls on the screens shown in Figures 3 and 4. These screens catch any large fused particles that fall off. Small ones, including all unfused granules that pass the screen fall into a box from which they are sucked back into the large vacuum hopper above the machine and are reused.

Flux from the head hopper is fed via a forked tube shown in Figure 3 at each side of the electrode to cover

Figure 4 — Rear view of a roll being built up by welding after preheating by gas torch at lower right. Unfused flux drops onto the screen and that falling through is sucked into an elevated hopper and is reused. Ground brushes at upper right bear on the faceplate outside diameter.



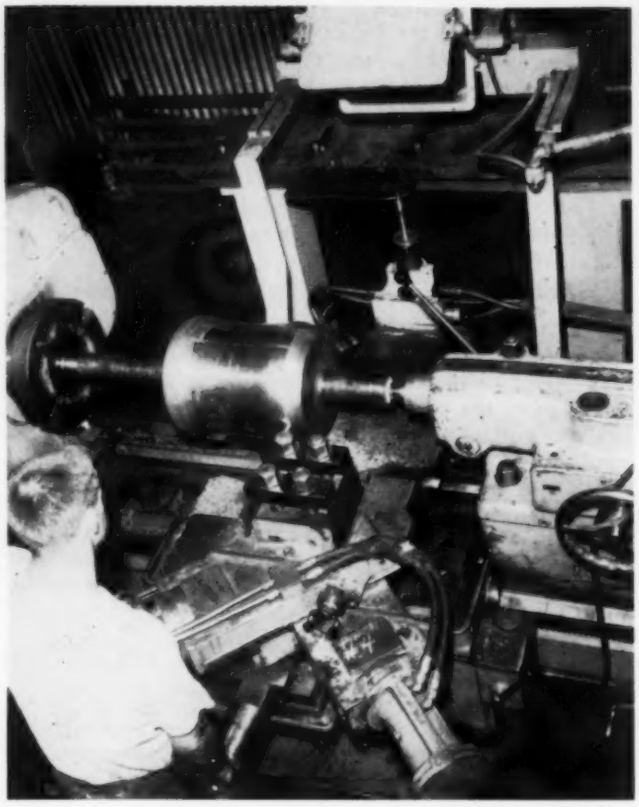


Figure 5 — Roll is turned after the weld build-up in a lathe having a hydraulic duplicator that causes the cutting tool to follow the same contour as the tracer against the template edge in the background.

the arc. An asbestos fabric wiper supported against the roll rides over its surface forward of the arc and helps to keep flux from falling off the front of the roll. New flux is added as consumption requires to keep an ample supply in the hoppers. That fused and caught on the screens is discarded.

Choice as to the type of electrode wire and flux depends upon the particular conditions to be met. On necked pipe straightening rolls which are forged from A-72 alloy steel, 0.65–0.75 per cent carbon wire and a mild steel welding flux have been used. Better results have been attained, however, by using $\frac{3}{16}$-in. mild steel wire and a half and half mixture of the mild steel flux and a new alloy flux. This is an agglomerated flux containing alloying agents chromium, molybdenum and vanadium. This combination costs about half as much as that involving alloy wire containing the similar alloying elements. The alloys are added to the weld deposit through the flux rather than through the wire, and the alloy can be varied by changing the mixture of fluxes.

In building up cast steel crane wheels and brake drums, $\frac{3}{16}$ or $\frac{5}{32}$-in. high carbon wire and flux mixture previously described have given good results at lower cost than for alloying set-ups. Such welding increases the diameter of the part about $\frac{3}{8}$ in. per pass.

Feed rolls for the tube mills which must have hard surfaces that are ground, have been built up in some cases by using chromium-molybdenum-tungsten wire and the flux mixture. Choice of wire and flux depends upon the base metal of the roll, upon the particular service conditions to be met (such as hardness and toughness) and upon which combination gives best results at moderate costs.

Before welding starts all rolls are heated to 300 to 400 F. This could be done to advantage in a furnace, but until one has been installed, heating has been done with a flame from the hog burner shown in Figure 4 while the roll is rotated slowly in welding position. After this preheating, the roll surface is wire brushed before welding. During the welding, the arc supplies ample heat to maintain the desired temperature.

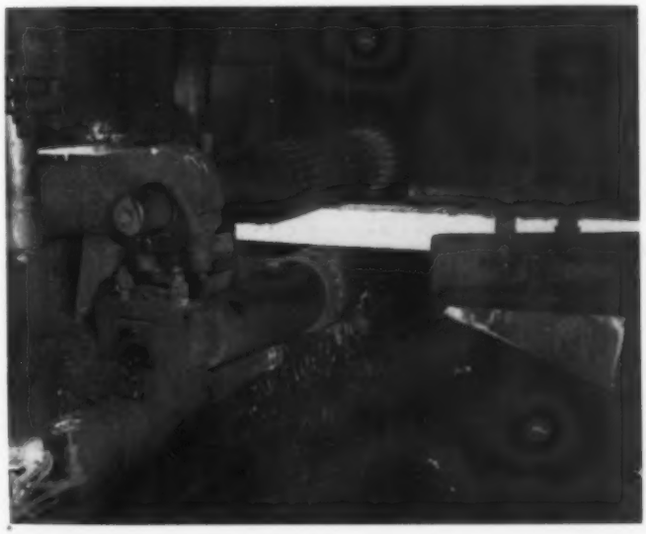
During the welding process a carriage feed of about $\frac{1}{4}$ in. per revolution is usually maintained and rotary speed for a roll of about 12 in. approximates one turn a minute. Although the beads appear to be individual and resemble rope like coils, each turn fuses perfectly with the adjacent one, and after subsequent turning, the surface obtained is as smooth as that of a new roll. Life tests, however, indicate that the built-up surface is considerably more resistant to wear than is that of a new roll. Several layers of welding usually are required. Some rolls have been increased as much as 3 in. in diameter by successive layers of weld beads.

All build-up work done on rolls in this plant involves high hardness and toughness, yet the metal deposited is readily machined with either high speed steel or carbide tipped bits. Such machining is done in a lathe, Figure 5, equipped with a hydraulic duplicator whose tracer follows the contour of a template of the desired shape. When used with the duplicator, the tool bit is forced to follow the same contour as the template, and so gives the roll a necked or other shape the same as the template contour.

Besides building up surfaces of rotation, the welding set-up, Figure 1, can be used to produce longitudinal beads along the roll surface. In such cases, of course, the roll remains fixed, rotation being stopped, and longitudinal motion is imparted to the welding head by moving the carriage along its ways by the lead screw at a comparatively high speed. If the roll is not cylindrical, vertical adjustment by the hand wheel is required.

This type of set-up has been employed on furnace pinch rolls used to advance heated billets into skelp

Figure 6 — Pinch roll is built up with longitudinal beads to provide improved gripping action and longer life. These billets are leaving the billet heating furnace prior to being rolled into skelp.



mills as seen in Figure 6. Formerly these pinch rolls were fitted with longitudinal keys that were welded onto the surface. Such keys were subject to rapid wear and gave other trouble. They are now replaced by longitudinal beads laid down in two passes, the beads being about ½ in. wide and ½ in. high above the adjoining cylindrical surfaces.

Some such beads have been produced by chromium-molybdenum-tungsten wire with the flux mixture. The bead is of chrome-nickel alloy and is both tough and hard. Original pinch rolls with keys would run 6000 to 9000 tons of steel before the keys had to be renewed.

One set of rolls with the weld bead serrations ran 11,866 tons and another 16,089 tons before serrations wore enough to require renewal. Labor and material for renewal cost about 40 per cent of the cost of a new roll (for a roll of 12 in. base diameter and 60 in. long). Reworking requires about 24 man hours of labor and time out of service is much shorter than for repairs of rolls with keys.

In the case of pipe straightening rolls, such as appear in Figure 1 which are 14¼ in. at maximum diameter and 17½ in. long, the cost of build-up by welding and machining is a little more than one third of the cost of a new high carbon steel roll forging.

Both labor and material costs depend, for a given size of roll, upon the amount of build-up required and on the type of wire and flux used. In some pipe straightening rolls, the small diameter is built up by 3 in. say from 11½ to 14½ in.

Although experience here outlined covers only a few months, and improvements in practice are still being made, the results have shown large savings that much more than justify the equipment investment required. At present, the welding set-up is kept busy 24 hours a day and will be needed to handle still more work as soon as a preheating furnace (which will shorten the time per roll in the lathe) can be installed. All indications point to additional applications in building up other types of rolls as well as to a marked reduction in the number of new rolls that will have to be purchased for a given total output.

By J. GOLDSTEIN, General Foreman, Welding Shop, Inland Steel Co., East Chicago, Ind.

ECONOMICAL ROLL RECLAMATION

. . . . the weld shop at Inland is a very important factor in their maintenance program . . . .

▲ SUBMERGED arc welding is an automatic, electric, arc welding process in which a granulated welding composition called melt, is automatically laid down in advance and completely surrounds the electrode. The welding takes place beneath the melt and thereby conceals the arc. The high amperages used in relation to the wire size results in high welding speeds, deep penetration, exceptionally high quality metal deposits and minimum distortion.

Our welding shop at Inland Steel Co. is equipped with four submerged arc welding machines. Each is differently designed for versatility which is so essential in maintenance welding.

Machine No. 1 was built in 1945 and was designed for the work to move while the welding unit remained stationary. The welding unit and all necessary controls and accessories are mounted on an 8-ft arm, which is so constructed that an extension can be added to increase the length if necessary. This arm in turn is attached to a 12-in. extra heavy, machined pipe so that the entire unit can be manually rotated. It also can be raised or lowered automatically by means of an electric motor.

A heavy duty, six-wheel carriage, driven by a 5-hp, d-c, adjustable speed motor, carries the work under this unit. When cylindrical welding is to be done, a set of variable speed turning rolls is mounted on the carriage.

Machine No. 2 was built in 1946. An obsolete 60-in. lathe was converted into a roll reclamation submerged arc welding unit. Similar to machine No. 1, the welding unit and all necessary controls and accessories are mounted on an arm approximately 3 ft in length. This arm rotates on a 7 in., extra heavy, machined pipe and can be raised or lowered automatically to suit each particular job. A 5-hp adjustable speed motor which is controlled by a rheostat, in conjunction with a reduction set, gives it a speed from 1/7 to 1 rpm.

The benefits and possibilities of the two submerged arc welding machines became more pronounced daily and before the year 1949 expired, a third, self propelled, submerged arc welding machine was designed. The design for machine No. 3 was basically similar to machine No. 1 except that in this case the machine travels and the work remains stationary. With this type of unit, flexibility has no limits, for it is possible to set up a number of jobs and start or finish them as necessary without disturbing any particular set up. Then again at the same time, adjustable speed turning rolls can be used to weld any or all cylindrical jobs.

With the success of jobs performed for the various mills throughout the plant, mill personnel became aware of the great possibilities of reclamation of rolls, wheels, axles, shafts, etc. In return, the amount of work increased to such a degree that when a 36-in. obsolete

lathe became available, we designed our machine No. 4. This unit is mounted on the lathe and the general design is very similar to machine No. 2.

The welding power for all the units is obtained from banks of two, three, and four 500-ampere, 25-cycle, a-c transformers. Current can be limited to one individual transformer per each machine. This enables constant, uninterrupted operations in the event of failure of any one unit. In turn the current can be remotely controlled by the controls mounted at each welding unit head.

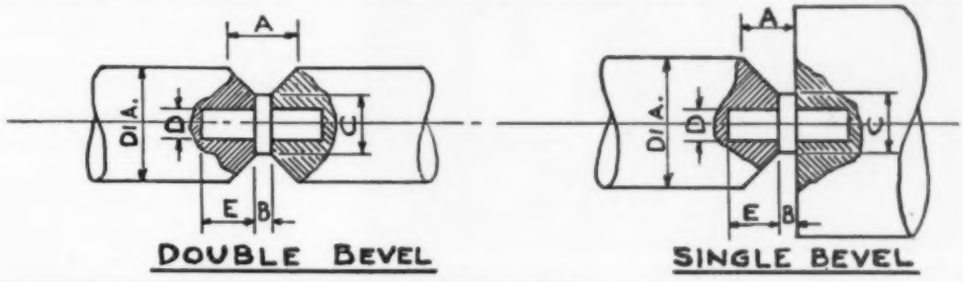
This paper will confine itself to the reclamation of rolls by the submerged arc welding process: that is build up of roll bodies and journals and stub-end welding of roll journals.

The basic electrode wire necessary for this type of reclamation and carried in our Inland stores stock is as follows: mild steel, SAE 4140, SAE 6150, SAE 420, and a chromium-tungsten-molybdenum wire. In particular cases, where it has been determined that a special type wire is needed for the welding application, the purchase of this wire is made special.

To properly plan welding procedures, it is necessary to know the chemical composition of the job being welded, and if this information is not readily available, we rely upon the metallurgical department of our main laboratory to furnish us the necessary analysis.

Reclamation of rolls, is done for many purposes. The big factor is economy. Also, reclamation helps solve the problem of large inventories of spares, for we can accommodate the mill requirements very satisfactorily. Finally, the life of the rolls reclaimed through this process is prolonged by increased wear and strength.

Reclaiming of our mill runout table rolls has proven so successful, that it is a constant source of supply for



DIAMETER	DOUBLE BEVEL A	B	C	D	E	TYPE OF WELD	SINGLE BEVEL A	B	C	D	E	TYPE OF WELD
2"	3/4"	1/4"	1/2"	3/8"	2"	M	1"	1/4"	1/2"	3/8"	2"	M
3"	1"	1/4"	1/2"	3/8"	2	M	1"	1/4"	1/2"	3/8"	2"	M
4"	1 1/8"	1/4"	1"	3/4"	2 1/2"	M	1 1/8"	1/4"	1"	3/4"	2 1/2"	M
5" & 6"	1 1/4"	1/4"	1 1/8"	7/8"	2 1/2"	M	1 1/4"	1/4"	1 1/8"	7/8"	2 1/2"	M
7" & 8"	1 1/2"	3/8"	2 1/2"	2"	3 1/2"	U.M.	1 1/2"	3/8"	2 1/2"	2"	3 1/2"	U.M.
9" & 10"	1 5/8"	5/8"	3"	2 1/2"	4"	U.M.	1 5/8"	5/8"	3"	2 1/2"	4"	U.M.
11" & 12"	1 3/4"	3/4"	3 1/2"	3"	4 1/2"	U.M.	1 3/4"	3/4"	3 1/2"	3"	4 1/2"	U.M.
13" 14" & 15"	2 1/8"	7/8"	4"	3 1/2"	4 1/2"	U.M.	2 1/8"	7/8"	4"	3 1/2"	4 1/2"	U.M.
16" & 17"	2 3/8"	1 1/8"	5"	4 1/2"	5 1/2"	U.M.	2 3/8"	1 1/8"	5"	4 1/2"	5 1/2"	U.M.
18" & 19"	2 3/4"	1 1/4"	5 1/2"	4 1/2"	6"	U.M.	2 3/4"	1 1/4"	5 1/2"	4 1/2"	6"	U.M.
20" 21" & 22"	3 1/2"	1 1/2"	6"	5 1/2"	6"	U.M.	3 1/2"	1 1/2"	6"	5 1/2"	6"	U.M.
23" & 24"	3 7/8"	1 3/4"	6"	5 1/2"	7"	U.M.	3 7/8"	1 3/4"	6"	5 1/2"	7	U.M.
25" & 26"	4"	1 7/8"	6"	5 1/2"	7	U.M.	4"	1 7/8"	6"	5 1/2"	7	U.M.

Figure 1 — Chart shows standards for roll preparation for welded joints. Letter M indicates manual weld and UM submerged arc.

Figure 2 — Illustration shows blooming mill crankshaft being prepared for welding.

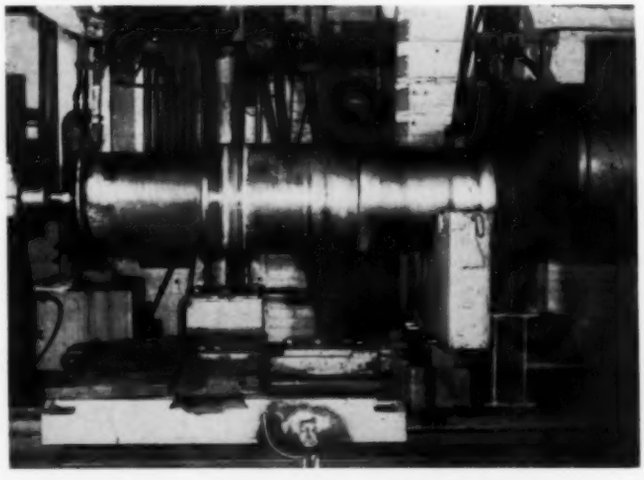
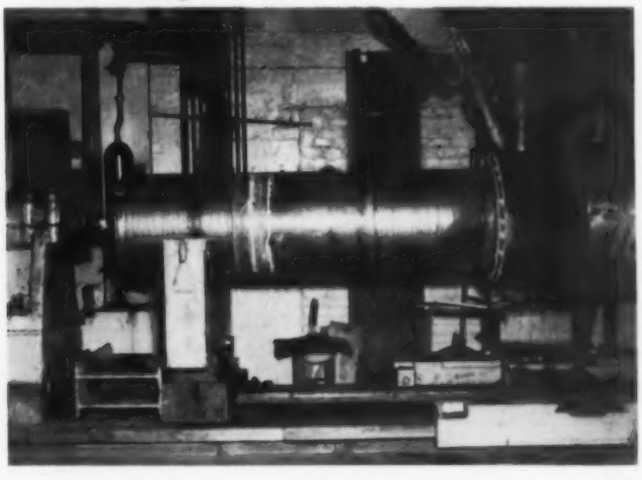


Figure 3 — Illustration shows blooming mill crankshaft after welding.



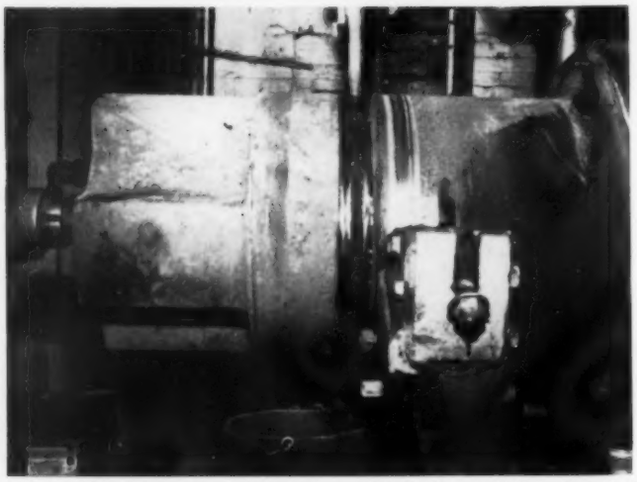


Figure 4 — Rotary set-ups are ideal for welding round pieces such as rolls.

our submerged arc welding units. In the reclamation of these rolls we usually have them sent to our machine shop before welding to have a skin cut taken off to remove any glaze. No preheating being necessary on this type of roll, we proceed to build it up with a mild steel wire. The voltage, amperage, and variac setting are determined by the size wire used which in turn is determined by the diameter of the roll to be welded. Weld metal is deposited to ¼ or 5/16 of an inch above finished size to allow stock for machining. After machining, the roll is the same as a new roll and in many cases gives longer service than the original casting.

As for our mill approach table rolls where not only wear, but heat cracking is also a problem, we have the body of the roll undercut till all the cracks are removed. Then we again use the same process as mentioned above, with one exception. Instead of mild steel wire we use a higher carbon wire with a heat crack resistant element, such as molybdenum. By using SAE 4140 wire we double the life of the reclaimed roll over the original casting.

Exceptional results have also been obtained through the reclaiming of pinch rolls. Multiple layers of chromium-tungsten-molybdenum wire are deposited to a size of 3/16 in. above finished size, in the same manner of build up as in the above mentioned rolls. A brinell hardness of 550 to 600 is acquired through this welding application, adding to the life of the roll to the extent that new rolls are now very seldom purchased. The increased life has saved much time and labor in decreasing shutdowns due to roll changes. If a new roll is required, it can readily be made by procuring a forging in the SAE 1040 range having it undercut ½ in. on the diameter below finished size and then building it up as described above. We have several of these rolls now in service.

Besides rolls there are a variety of other jobs in which a similar application is made with the exception of machining before welding. Brake wheels, crane wheels, car axles, cable drums, tension reel cones, etc., are a few examples. These are reclaimed with a type wire suited for each particular part in relation to its chemical composition and its service.

Alloy as well as high and low carbon journals are reclaimed by submerged arc welding. Recently we reclaimed the bearings of a mill work roll containing over 3 per cent carbon. Undercutting the journals ¾ in. on the diameter, the roll was then preheated to 400 F and set up in the 60-in. lathe. It was multiple pass welded to ¼ in. over the finished size. The primary pass contained some porosity, but this was completely eliminated with the subsequent passes deposited. We used a nickel-molybdenum wire, and the results were very gratifying. The welded surface finished to a clean high polish and is proving most satisfactory in service.

Broken roll necks from table rolls up to mill work rolls is another major repair problem that has been simplified through careful plan procedure and the minimum of submerged arc welding.

In most cases it is not feasible to weld the broken part back onto the roll because it is extremely difficult to align. The part is usually quite badly worn, twisted or battered, and the nature of the break may not permit the desired type of preparation for welding. To take care of these problems, we order a forging or casting with enough stock for machining. The machine shop prepares the joint, pins and fits it as per specifications on the chart that we have outlined for this type of work. Before preheating the roll, the veed joint to be welded is wrapped with asbestos, to prevent the flame from contacting the metal to be welded. This precaution is necessary to eliminate the forming of a hard scale at the weld joint. The roll is slowly preheated to 400 F before welding.

The roll is set up in either our 36 or 60-in. lathes, depending upon the size. The weld is made with a mild steel wire of either ⅛ or 5/32-in. diameter. Welding is a continuous process and once it is started it is not stopped until the weld is completely finished. The roll is then removed and allowed to cool normally.

Roll necks up to 26-in. diameter and as high as 0.8 per cent carbon have been successfully welded by this method. Most welds of this type are made on rolls, pinions, shafts, spindles, etc.

We attach as much importance to record keeping of jobs performed as we do to planning the welding procedure itself. In our file, listed according to departments, are records of jobs including such data as: preheat temperature, the size and type wire, welding speed, amperage, voltage, variac setting, part name, blue print number, and welding sequence. On special welding procedures, additional remarks are typed onto the record card. Included on this record card is a miniature sketch of the job, showing the type of weld and the approximate location. All this information proves to be especially essential in planning similar jobs or the routing of repeat jobs.

Our welding program at Inland Steel Co. has expanded immensely since the institution of the submerged arc welding. Jobs, that had previously been passed up due to design and the enormous amount of welding required, are now done today as simple, ordinary assignments. Rolls, spindles, etc., that had been scrapped in the past are being reclaimed today at great savings, as can be substantiated by the number that have been done in the past year. For example 125 spindles, 100 roll bodies, and 200 necks and journals have been reclaimed. This constitutes only a small percentage of all the jobs actually welded on these machines during the past year. Utilizing the possibilities of submerged arc welding has proven a great asset and helped make the weld shop at the Inland Steel Co. a very important phase of maintenance.

MAINTENANCE ASPECTS of Corrosion Program at Fairless Works

By K. L. JOHANNSEN, Division Superintendent of Maintenance and Utilities,
Fairless Works — Central Operations, United States Steel Corp., Fairless Hills, Pa.

K. L. JOHANNSEN

. . . . corrosion program at this plant should serve as a model for many future plants . . . .

▲ MANY technical papers, books and magazine articles have been written to explain the theories and scientific advances in the field of corrosion. See the first five references in the Bibliography at the end of the paper. However, the advent of these technical approaches and their corrective measures have presented maintenance personnel with the problem of revising laboratory test procedures for use in plant maintenance programs. The intent of this paper is to describe the maintenance procedures necessary to enable a full analysis of the features offered by the design of a modern steel plant having a nearly complete, corrosion-resistant, underground installation. First, it may be well to discuss briefly some of the more basic aspects of underground corrosion.

All corrosion is electrochemical in nature. This means,

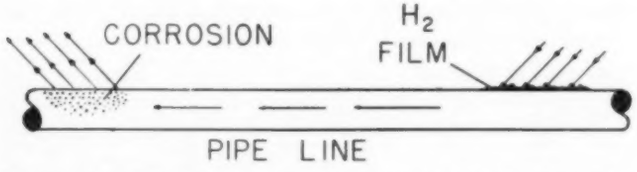


Figure 1 — When the current leaves the pipe, it carries some metal with it.

by application of Faraday's Law: "If an electric current of I amperes is made to pass through an electrolytic cell, consisting of two metal electrodes immersed in a solution of an electrolyte, then, in the absence of secondary effects, the velocity of the corrosion suffered by the anode will be I/F gram-equivalents per second, where F is Faraday's Number (96,500 coulombs per gram-equivalent). This means that one ampere hour will dissolve 1.04 grams of pure iron (as ferrous salt), 1.22 grams of zinc or 3.86 grams of lead." Substituting in the formula, one ampere of current acting on an underground installation over a period of one year can remove as much as twenty pounds of steel. Thus it is realized that smaller quantities of current flowing for greater lengths of time will destroy appreciable amounts of steel. Corrosion will always appear where this electric current leaves the underground installation.

Figure 1 shows an electric current entering and leaving a pipe line. When the current enters the pipe, a thin film of hydrogen will be deposited much the same as it tries to deposit on the carbon pole of a flashlight battery. Conversely, when the current leaves the pipe it carries ions of metal with it. These ions go into solution with the moisture in the soil and are exchanged for hydrogen

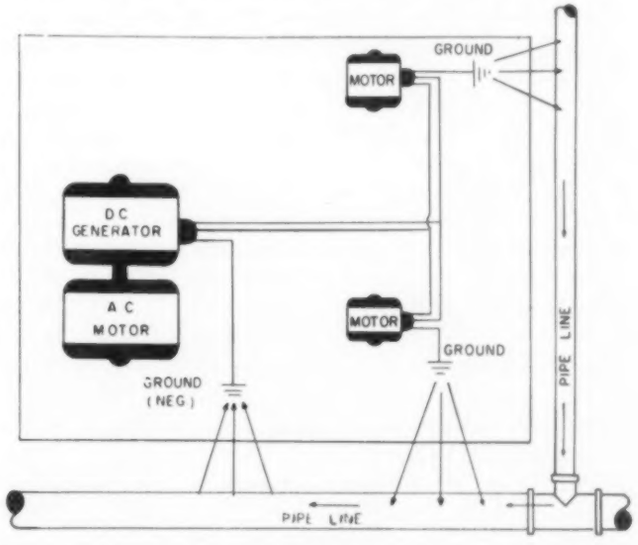


Figure 2 — Stray currents occur as a result of grounding procedures.

ions, leaving the iron behind as a rusty scale and the cycle is completed.

Corrosion can be divided into three types; namely,

1. *Stray current corrosion* — Stray d-c currents are present in the soil due to grounding procedures used around large electrical equipment. In Figure 2, we see current leakages from mill motors being picked up by a pipe line, traveling along that pipe line, and returning to the motor-generator set through a negative ground.
2. *Galvanic corrosion* — Two dissimilar metals in electrical contact are placed in an electrolyte thus forming a galvanic cell. An electric current, called a "galvanic current," will pass between them causing one of the metals to corrode. Figure 3 shows a steel pipe connected to a brass valve. The current will flow from the steel to the brass causing the pipe to corrode. The electrolyte is often moisture and soluble salts in the soil.

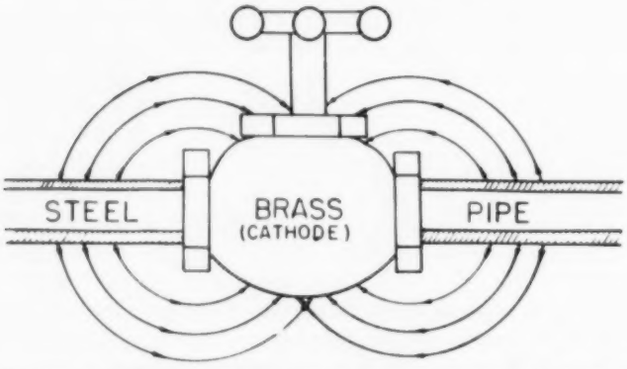


Figure 3 — Galvanic corrosion occurs when dissimilar metals are connected together.

3. *Local-cell corrosion* — This is caused by the same metal being subjected to differences of potential in a common environment, such as dissimilarity of surface conditions or differences in soil structure. Figure 4 shows a pipe running through different types of soil. The current flows from the clay soil area to the sandy loam area and the pipe corrodes.

Damage by corrosion to installations above ground is readily recognized: for example, rusting of steel, leaks in piping, and painting problems. However, underground equipment failures are difficult to recognize and not too readily associated with corrosion by some maintenance people. After repairs are complete, they direct their attention to another failure and its repair rather than spend time investigating the premature rupture of a pipe section, cable or structure settlement.

Industrial plants, particularly steel plants, have been combating the problem of corrosion for years. Public utilities were among the first groups to organize against the enemy, corrosion. They have tried to reduce damage within their means of regulated maintenance costs while reducing production stoppages. As a result of their effort, great strides have been made in underground corrosion work.

A few years ago the United States Steel Corp., being cognizant of high maintenance costs and production stoppages that are directly attributable to corrosion, embarked on a program of corrosion control and education in conjunction with the research and technology department. The initiating of field surveys on existing above-ground and underground installations was emphasized. This work was conducted by plant personnel with someone serving as corrosion engineer and, in some cases, in cooperation with a qualified outside consulting service group.

The underground corrosion program at Fairless

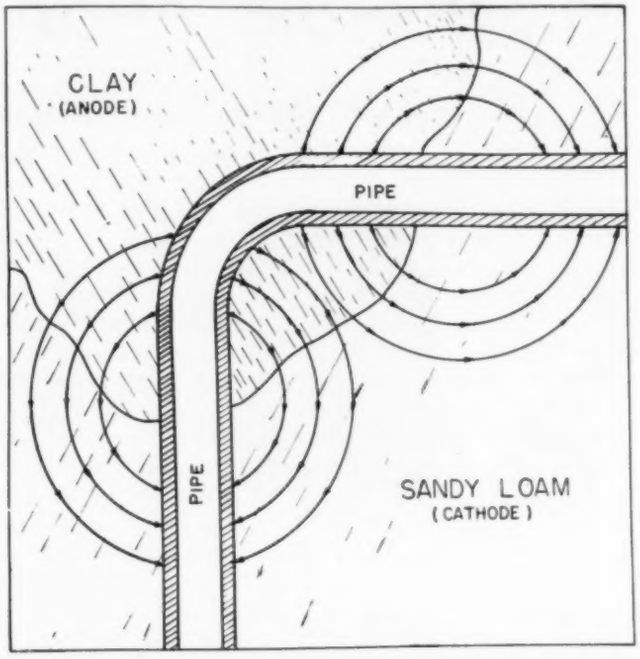


Figure 4 — Pipe running through different types of soil may be subjected to local cell corrosion.

Works, is applicable in some respects for other steel plants. When corrective measures are made in older plants, the same basic program can be adjusted to their individual plant practices.

The metals that present the most concern in underground corrosion problems are steel and lead, because they are used underground in large quantities and are susceptible to corrosion. This corrosion can be retarded with the proper type of protection. The passage of an electric current, from either lead or steel through the earth as an electrolyte, will accelerate corrosion at the place where the current leaves the metal. If the metal is kept perfectly dry or the earth current stray is

Figure 5 — Grounding design eliminated effect of dissimilar metals in contact with the earth.

eliminated, corrosion will be greatly retarded or eliminated.

One of the basic features at Fairless Works was the elimination of all copper grounding rods, and bare copper wire commonly used for establishing low resistance ground sources thus reducing a source of galvanic corrosion.

All the magnesium and steel ground rods are cadweld, Figure 5, connected with 250 MCM neoprene covered and taped copper cables. This design greatly minimizes undesired galvanic corrosion by the elimination of dissimilar metals in contact with the earth.

Magnesium, being anodic to steel, is buried in a definite pattern near the steel ground rods to protect them. The relationship of these metals in the electromotive series provides a potential between the steel and magnesium, thereby resulting in a protective current

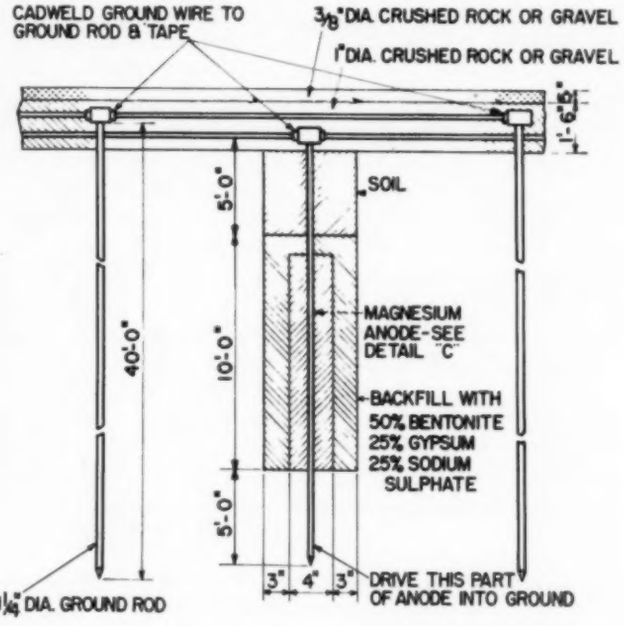


Figure 6 — Connections for grounding are illustrated here.

flow in the earth from the magnesium to the steel. This is known as cathodic protection with the magnesium acting as the corroding member.

A unique feature, playing an important role in the corrosion testing program at Fairless Works, is the use of clearly marked ground beds. The high earth resistivity necessitated the use of many, long ground rods to obtain low contact resistance to earth.

The steel grounding rods are forty-ft long, 1¼ in. in diameter, weigh approximately 160 lb, and are connected as shown in Figure 6.

Each magnesium anode, Figure 7, is a twenty-ft long, one-in. in diameter, steel rod with a four-in. square by ten-ft long magnesium coat at mid-length. This design eliminated one ground rod and still satisfied the value of one milliampere of current flow per square foot of exposed steel. At Fairless Works, we use magnesium alloys AM265 and AM266 for the anode casting.

The maintenance corrosion program serves many interests at Fairless Works, but its primary purpose is three-fold.

1. To locate the presence of d-c stray currents when they occur and remove them or eliminate their harmful effects before they become destructive to underground installations.
2. To determine anode life for future replacement by obtaining test data and evaluating this data for the purpose of making these replacements on existing installations.
3. To obtain test data for use in designing future systems at Fairless Works and other United States Steel Corp. plants.

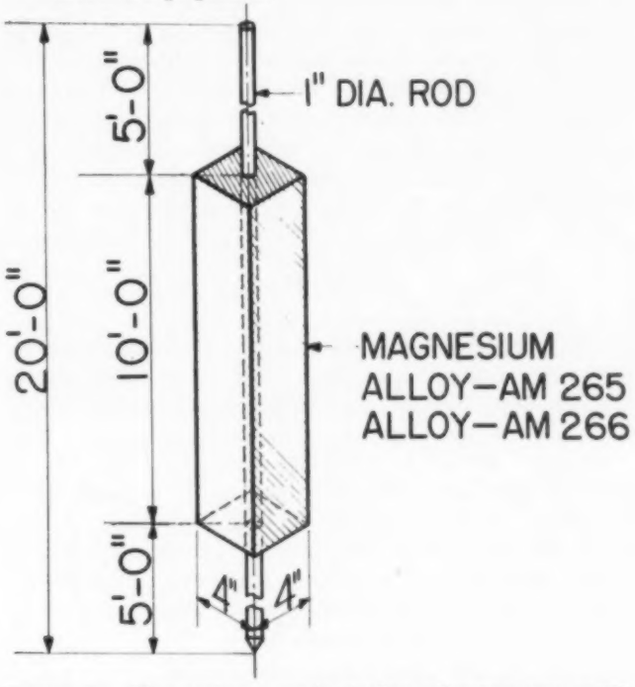


Figure 7 — Magnesium anode design allowing one milliampere of current flow per square foot of exposed steel.

The maintenance corrosion program involves tests at 35 transmission towers, 28 substations, 26 building areas, and a fuel oil storage tank. Tests for corrosion at these locations are set forth in a definite procedure and follow a schedule for periodic evaluation. The program is headed by the corrosion engineer who is the maintenance engineer (electrical) at Fairless Works. All routine maintenance and tests are performed by the central maintenance electrical test and communication shop

Figure 8 — Test plate shown is located on one of the 69-kv substations.

personnel. The test data is forwarded to the corrosion engineer who issues all shop orders for routine tests, maintains records, supplies test forms, educates test personnel on special procedures, and reports all findings to plant management and the United States Steel Corp. research and development laboratory.

Since accuracy is very important in the test program, written procedures were developed and followed with field supervision in the initial testing to instruct test personnel. The first step in the corrosion program was to properly identify the ground bed networks at the test plates, described in detail below. This insured that the references needed for future tests would be preserved and thus permit periodic comparisons on the individual beds. The annual and semi-annual tests will serve as the basis for evaluating the condition of the ground bed.

SUBSTATIONS

The substation grounding system design offers easy access for testing the condition of the magnesium anodes and the steel rods. A copper test plate located above ground in each area provides this means.

Figure 8 shows a test plate located in one of our 69-kv substations. The copper plate is supported by insulators on the wall of the control house. At this particular substation the building ground grid is tied to 64 steel rods and 32 anodes. The local transformers, cable sheaths, and switchgear are connected to the steel

SUBSTATION GROUNDING TEST

(SEMI-ANNUALLY)

Location _____ Date _____

Weather _____ Made By _____

1. Current between Magnesium and balance of ground network at test plate _____ Mg. Polarity _____
2. Potential between Magnesium and balance of network at test plate _____ Mg. Polarity _____
3. Resistance to Ground of Magnesium _____ ohms
4. Resistance to ground of complete ground network _____ ohms
5. Resistance between magnesium and balance of ground network _____ ohms

Figure 9 — This form is used to record test data obtained at substations.

rod ground cable. These network connections are made with neoprene jacketed cable placed in a layer of crushed stone. Spacing of the ground rods was designed to offer the best possible surface potential gradient for ground fault currents.

Testing is confined to current, voltage, and resistance measurements with particular attention given to the polarity of current and voltage. Polarity plays an important part in ground bed condition evaluations.

Figure 9 shows the form used to record test data obtained at substations. Note that this test is performed semi-annually. Pertinent information such as date, location, temperature, and test personnel initials are necessary to recheck any unusual test results. Current and potential readings are taken directly from the plate, but resistance measurements are taken using the three terminal ground resistance method as illustrated in Figure 10.

Two steel stakes are driven into the ground at distances of five times the maximum dimension of the grounding bed and five times the maximum dimension plus one hundred feet from the test plate. These two

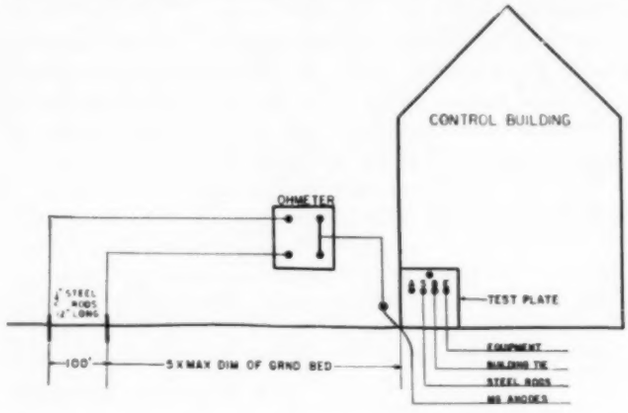


Figure 10 — Resistance measurements are taken using the 3-terminal ground resistance method.

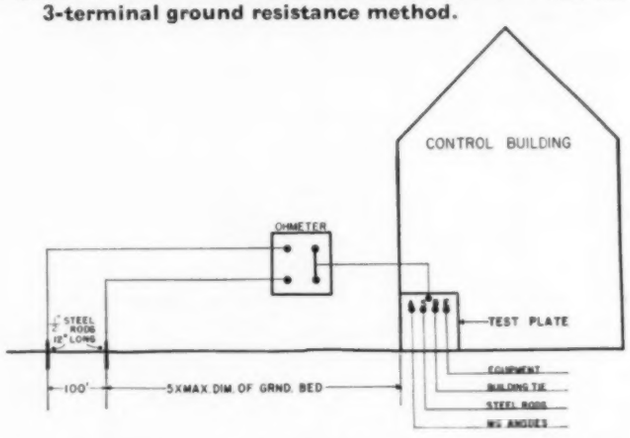


Figure 11 — Meter is connected in circuit to measure distance to ground of the complete network.

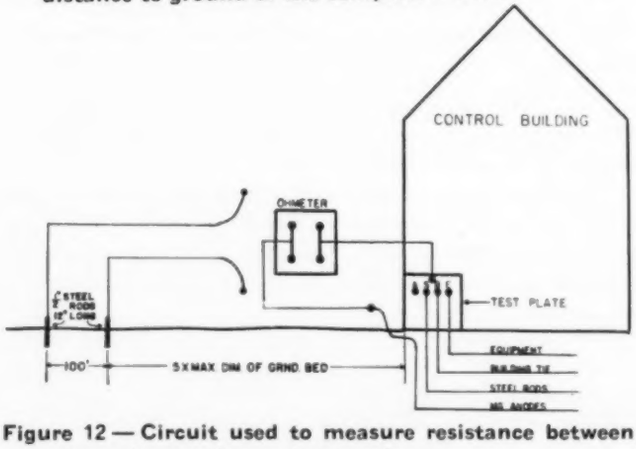


Figure 12 — Circuit used to measure resistance between magnesium and rest of network.

stakes are then connected electrically to a three or four terminal ground resistance meter. The magnesium lug is disconnected from the test plate and connected to the other terminals of the meter to measure the resistance to ground of magnesium.

The meter is connected in the circuit with respect to the test plate to measure the resistance to ground of the complete network (Figure 11).

Figure 12 shows the magnesium lead is disconnected

TABLE I

Substation Ground Bed Test

(Fall 1953)

Location	Bed No.	Mg (Anode)		Resistance			Steel
		Ma	E	Mg	Mg to net	Net	Ma/sq ft
Pump house — 69 kv	40	+900	+0.58	0.50	0.04	0.50	
River pump — 2.4 kv	41	—560	—0.62	0.95	1.00	0.015	10.72
Waste treatment — 2.4 kv	42	—342	—0.56	2.15	1.825	0.35	3.73
Main sub — 69 kv	24	—940	—0.57	0.75	0.50	0.45	1.125

from the test plate and an ohmeter inserted between the lead and the test plate to measure the resistance between the magnesium and the rest of the network. For purposes of evaluation, the following readings are taken as normal:

1. Resistance to ground of outdoor substations — less than 1 ohm.
2. Resistance ground of primary indoor substations — less than 3.5 ohms.
3. Resistance to ground of secondary indoor substations — less than 7.0 ohms.

The first round of tests at seven substations have been taken and comparisons with the 1952 and 1953 construction records indicate the following:

1. No appreciable change in values for the main outdoor substation.
2. Ground rods in most of the other areas are receiving their proper protective current.
3. The design of magnesium anodes is functionally correct to overcome local corrosion cells and protect the steel rods.

Table I shows results from substation tests. Further investigations of the 69-kv pump house substation would be necessary because of the abnormal, reversed value of 900 milliampere positive ground bed current. The three other reports show voltage, current and resistance to be within proper limits. Cathodic currents are above the accepted minimum of one milliampere per square foot of steel rod exposed to earth.

BUILDING GROUND BEDS

Building ground beds serve to protect the underground structures against corrosion by galvanic currents of dissimilar metals in the earth and offer ties for grounding equipment to provide safety to personnel.

The test plate used in the building grounds is shown in Figure 13. Two cables are the ties to other building columns and the other two cables are connected to the local ground bed. Permanent identification of the circuits, A for anode, S for the steel rods, and B for building ties to other ground beds (not shown), is made directly above the lugs with a letter punch.

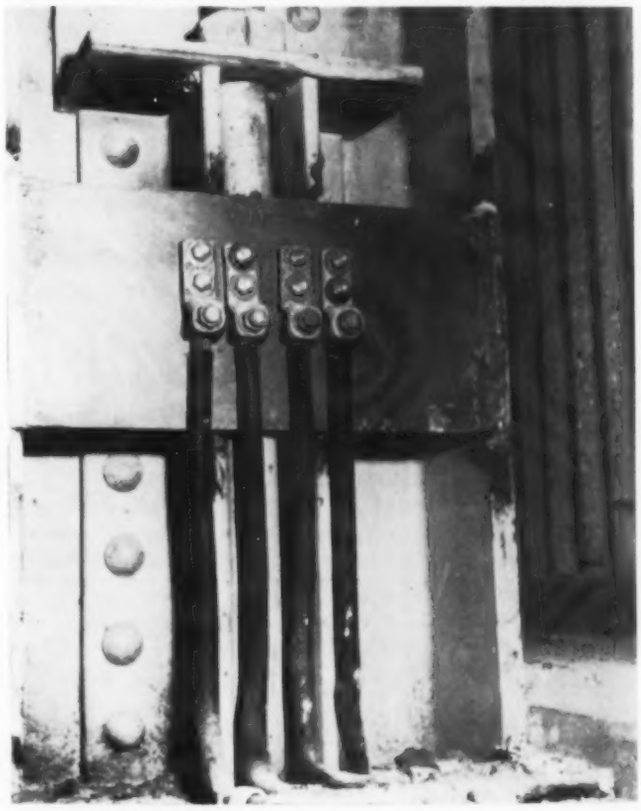
The building ground bed tests are more detailed and elaborate than the substation or transmission tower tests. This is due to the fact that both the steel rod cable and the anode cable can be safely removed from the test plate, whereas the steel rod terminal on the substation test plate must not be removed in order to maintain a good ground in event of a fault.

One measurement of current is made between the magnesium anodes and the balance of the network. This test is followed by milliammeter tests of the ground bed with the magnesium disconnected and then connected. The primary purposes are to establish the effect of the magnesium rods and to detect the value of local cell currents. Similarly, potential measurements are made to determine the voltage existing with the steel rod connected and then disconnected. Again, this serves as a check on the currents.

Resistance measurements of building ground beds are similar to those made at substation tests by obtaining the ohms to earth measurement of the magnesium, steel rods, and ground bed. Building ground beds are designed to have 3.5 ohms or less resistance to earth contact.

Figure 14 illustrates the building ground bed test sheet used in our maintenance program. Note that this test is performed semi-annually. The various tests are performed in numerical order to gain advantages of a

Figure 13 — Test plate shown is used in building grounds.



TEST OF BUILDING GROUND BEDS

(SEMI-ANNUALLY)

Location _____ Date _____

Weather _____ Made By _____

* 1. Current between magnesium and balance of ground network at test plate _____ Mg. Polarity _____

* 2. Current between ground rods and balance of ground network at test plate

(a) With magnesium disconnected _____ Gnd.Rod Polarity _____

(b) With magnesium connected _____ Gnd.Rod Polarity _____

* These values may be high if stray currents exist. Otherwise they will probably not exceed 200 ma.

3. Potential between ground rods and balance of network at test plate _____ Gnd.Rod Polarity _____

(a) With magnesium connected

(b) With magnesium disconnected _____ Gnd.Rod Polarity _____

4. Potential between magnesium and balance of network at test plate

(a) With ground rods connected _____ Mg. Polarity _____

(b) With ground rods disconnected _____ Mg. Polarity _____

5. Resistance to ground of magnesium _____ OHMS

6. Resistance to ground of ground rods _____ OHMS

7. Resistance to ground of magnesium and ground rods _____ OHMS

Figure 14 — Form used to record building ground bed test data.

low resistance path for current measurements before starting the high-resistance, circuit-potential tests.

Since building test beds are in areas of the most possible sources of stray current, detection of these harmful currents is quite simple. An unsteady pointer on the test instrument, or an ammeter reading greater than one ampere, requires further investigation due to the stray currents. A high resistance voltmeter and a copper sulphate half-cell are used to trace stray currents to the vicinity of their origin. Some times a profile study, consisting of a voltage ground plot, will help gain enough information to find the trouble spot.

Table II shows some typical building test results. Two areas have a high resistance to earth ground bed exceeding 3.5 ohms (bed No. 32 and No. 73). The cathodic current of 1.09 milliamperes per square foot of steel rod on bed No. 32 is nearing the allowable minimum limit for its design. If such a condition existed, further study would be needed to determine the means of correcting it.

TRANSMISSION TOWERS

The 35 transmission towers carrying 69-kv transmission lines at Fairless Works have a steel rod at each corner and the connecting cables are bolted directly to the transmission tower base instead of to a test plate. Testing is confined to resistance measurement only. Since the overhead static line connects all towers and 69-kv outdoor substations, hazard is reduced in the test. Each 40-ft steel rod is tested separately and should be under the design limit of 32 ohms resistance to earth. This is followed by a parallel test of the four rods to ground which should be under the design limit of 11 ohms resistance to earth.

Figure 15 shows a typical test sheet used for testing

TRANSMISSION LINE TOWER GROUNDING TEST

(ANNUALLY)

Location _____ Date _____

Weather _____ Made By _____

1. Resistance to ground of rod #1 _____ ohms
2. Resistance to ground of rod #2 _____ ohms
3. Resistance to ground of rod #3 _____ ohms
4. Resistance to ground of rod #4 _____ ohms
5. Resistance to ground of all 4 rods _____ ohms

Figure 15 — Form used to record transmission line tower grounding test data.

transmission towers annually. Each rod at the tower is identified numerically to permit maintenance of accurate records on the life and benefits of the rod.

Table III shows some results that might be expected from transmission tower tests. If these conditions existed, further investigation of the high resistance ground rods on the following towers would be necessary to remedy improper grounding:

1. Rod No. 1 on Tower 10.
2. Rod No. 3 on Towers 17 and 23.
3. Total network on Tower 20.

While all underground steel pipe was given a protective coating of tar compounds and tar impregnated wrapping before installation, our corrosion program includes proper checking and investigation with the aid of a voltmeter and a copper sulphate half-cell to highlight any areas that need attention, as well as gathering

TABLE II

Building Ground Bed Tests

(Fall 1953)

Location	Bed No.	Mg (Anode)			Stl (Cathode)				Resist to earth — ohm			Stl
		Stl in		Out	Mg in		Mg out					
		Ma	E	E	Ma	E	Ma	E	Stl	Mg	Net	Ma/sq ft
80-in. motor room	31	—405	+0.109	—0.36	+ 72	—0.68	—169	—0.92	0.50	0.72	0.10	2.38
Billet condition yard	32	—186	—0.71	—0.90	+ 50	+0.16	— 65	—0.29	4.75	5.5	4.1	1.09
Hot metal bay — oh	70	—270	—0.37	—0.40	+ 58	+0.102	— 23	—0.048	2.12	1.68	1.45	1.59
Mold preparation — oh	73	—350	—0.54	—0.78	+104	+0.18	—122	—0.35	4.60	4.5	4.5	2.06

TABLE III

Transmission Towers — Ground Tests

(Fall — 1953)

Resistance to Ground — Ohms

Tower	Rod 1	Rod 2	Rod 3	Rod 4	All rods
No. 10	82.5	10.0	12.75	16.5	5.0
No. 17	10.0	13.5	∞	9.5	4.5
No. 20	7.0	9.25	10.5	10.75	0.9
No. 23	8.8	8.5	42.5	8.9	3.6
No. 26	6.2	7.2	8.5	6.8	2.6
No. 29	8.4	7.6	6.3	8.5	2.7

data to help us determine what type of additional protection, if any, is economically justified.

Profile testing is done in the following manner. See Figure 16. One terminal of a voltmeter is connected directly to the pipe while the other terminal is connected to the copper sulphate half-cell. The half-cell is then placed on the ground above the pipe at intervals of fifty or one hundred feet and the voltage readings taken. These readings are recorded and plotted on a graph

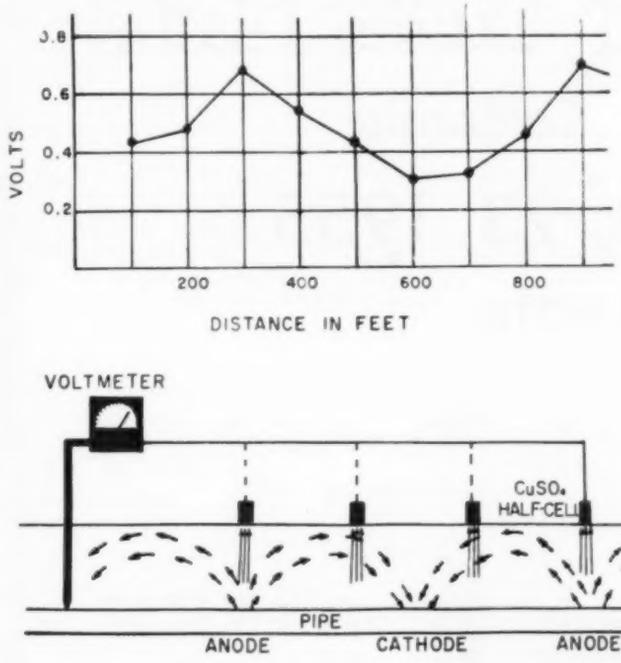


Figure 16 — Sketch shows method used in profile testing.

with voltage and distance as the coordinates. Exceptionally high or low voltage points indicate a condition that requires investigation.

While this paper is of necessity based on data and facts obtained over a relatively short period of time, we have accumulated sufficient data and information to verify that in nearly all cases the actual installation is meeting design aims and specifications. Only time, more data and experience will enable us to fully evaluate the effects of the corrosion prevention program now in existence at Fairless Works. The maintenance and utilities division has assumed the responsibility of gathering this data by the procedures described in this paper.

It is fully expected that the results of evaluations of this maintenance program and field data by our research and development laboratory and design engineers, plus our present methods of minimizing corrosion, will serve as a model for many future industrial plants.

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DISCUSSION

PRESENTED BY

HARRY H. ANGEL, Electrical Engineer, Bethlehem Steel Co., Bethlehem, Pa.

K. L. JOHANNSEN, Division Superintendent of Maintenance and Utilities, Fairless Works — Central Operations, United States Steel Corp., Fairless Hills, Pa.

Harry H. Angel: I happen to be on the grounding sub-committee of AIEE, and my particular work has been equipment grounding. That portion of a report covering sub-station fence grounding is based on the recommendations of a number of power companies and some of the consulting engineering organizations.

The recommendations indicate that the grounding is improved by driving copperclad ground rods. Now, a number of people have commented that the copper coating over the steel causes corrosion between the outer surface and the adjacent steel structures. It is something which Mr. Johannsen has commented upon, and there are a few individuals who think that the

copperclad ground rod should be replaced by a steel rod in spite of the fact that the elimination of the copper will increase the resistance. However, more work is being done by the power companies in handling this corrosion difficulty.

I also might mention that the Pennsylvania Power and Light Co., with headquarters in Allentown, is now using steel in ground mats. They have eliminated copper cable and copper ground buses entirely, as a result of trouble they have had in the past.

This steel matting consists of flat steel bars which are welded together and galvanized steel connections are brought above the ground for purposes of connecting to the building structures. They are cognizant of the difficulty from corrosion; I have not seen their test figures — but they seem to be pretty sure of themselves, because this new large Martin's Creek Power House, which is being installed north of Easton, on the Delaware River will have steel matting exclusively, outside and inside.

K. L. Johannsen: I think the power companies are probably faced with the same thing we are in most of the older plants, where it used to be common practice to dig a big hole and bury as much copper as you could for your grounding bed. Basically, if you analyze the electromotive series you will find that this is wrong if you have any iron in that same area. You will find that corrosion will take place in the form of iron to the copper. That is why we used steel in our grounding beds. We used the steel rods in place of the steel matting because in our case the soil resistivity is very high near the surface and better results could be obtained by driving long rods. To use steel matting we would have had to dig down rather deeply to get the same ohmic value for the bed.

AISE

WEST COAST MEETING

San Francisco, California

March 21, 22, 23, 1955

ST. FRANCIS HOTEL

PLAN TO ATTEND

Make your reservations

NOW!

Daily Maintenance COST CONTROL --the Foremen's Tool

By W. B. CARTER
General Superintendent of Maintenance
Alan Wood Steel Co.
Conshohocken, Pa.

. . . . a great deal of the clerical work has been eliminated by setting up cost control on business machines . . . .

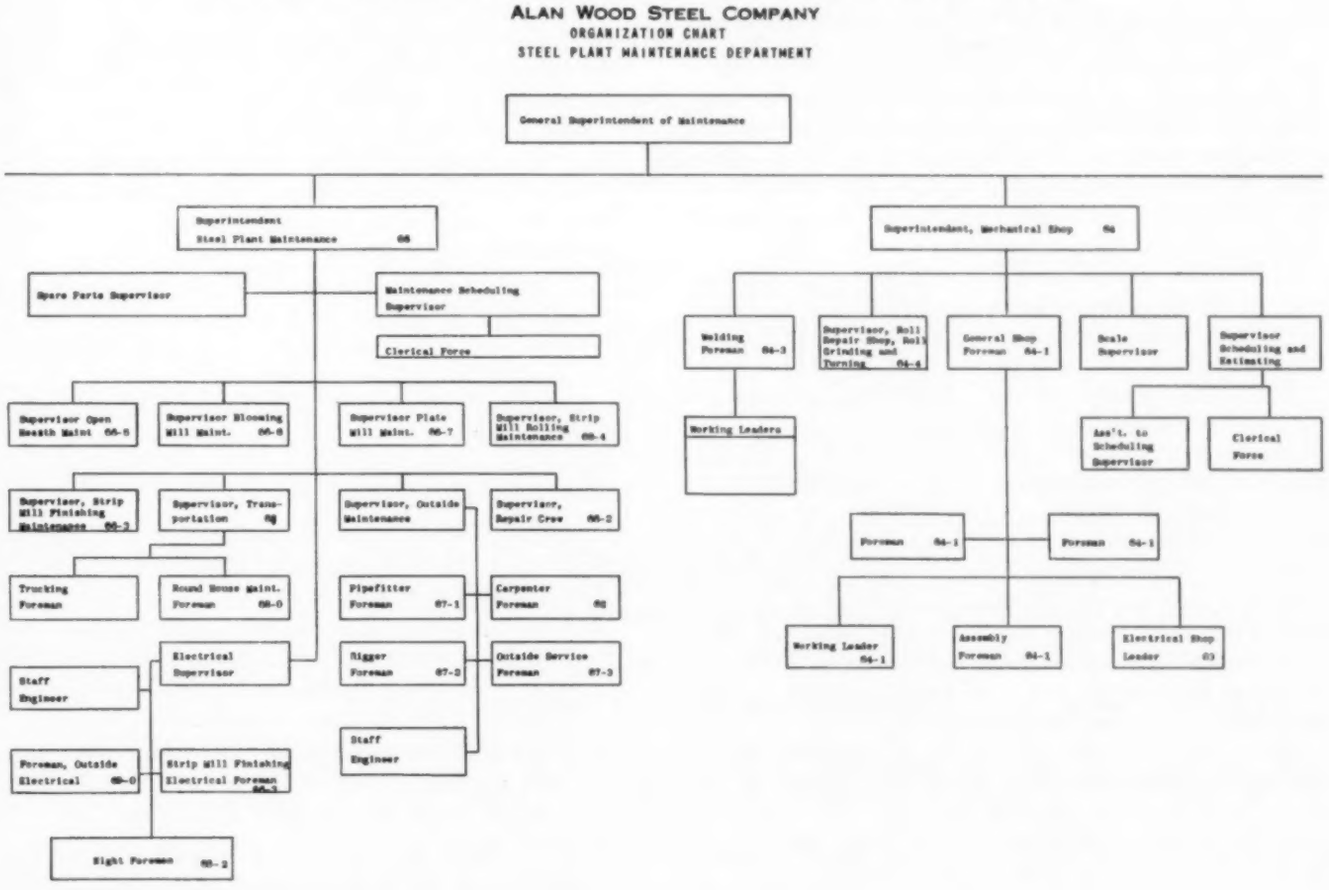
▲ THIS is the story of the development of a cost control system for the maintenance foreman. It starts in 1950, just after the installation of our hot strip mill. In addition to the increase in size due to the strip mill expansion, the maintenance department was completing the transition from an individual mill type organization to centralized maintenance.

The steel works maintenance department in 1950 consisted of the mechanical shops, mill maintenance groups and outside forces (that is, the crafts). See Figure 1. The numbers in each block represent the department numbers used in the daily control system.

With the exception of the mechanical shops, which required work requests for some types of jobs, all of the work was carried out through verbal requests. Not only the work to be done but the cost code to which this work was charged were transmitted verbally.

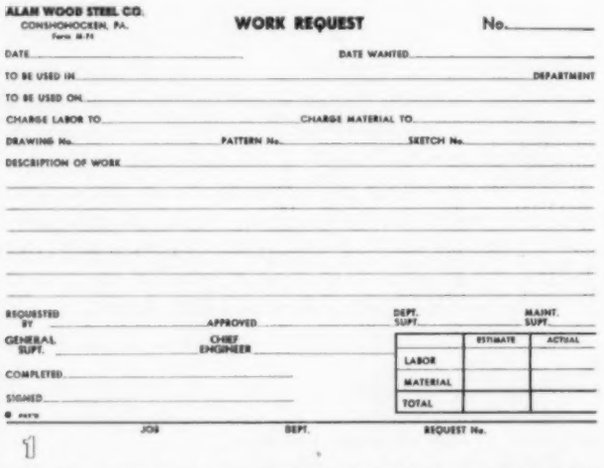
The cost reporting system consisted of daily time

Figure 1 — Numbers on organization chart are used in applying cost charges.



distribution direct to cost codes and monthly cost reports which were received the 20th of the month for the preceding month. It is evident that with such a system there is little real cost control. If a foreman tried, he had no way of measuring his performance since reporting was not adequate. And even if he obtained weekly reports which would be a tremendous improvement, he still had little control over his recorded costs since there was no way to prevent people from charging to his cost codes, whether he desired the work or not.

The initial step in daily cost control was to create a practical work request system which would accomplish three things: first, limit the use of cost codes to persons authorized to spend the money; second, provide a systematic approach to the backlog of work and insure getting "first things first"; third, provide a method for reporting and tabulating the results.


ALAN WOOD STEEL CO.
CONSHOHOCKEN, PA.
Form B-71

WORK REQUEST No.

DATE DATE WANTED

TO BE USED IN DEPARTMENT

TO BE USED ON

CHARGE LABOR TO CHARGE MATERIAL TO

DRAWING No. PATTERN No. SKETCH No.

DESCRIPTION OF WORK

REQUESTED BY APPROVED DEPT. SUPT. MAINT. SUPT.

GENERAL SUPT. CHIEF ENGINEER

	ESTIMATE	ACTUAL
LABOR		
MATERIAL		
TOTAL		

COMPLETED

SIGNED

JOB DEPT. REQUEST No.

1

Figure 2 — The work request is a 5-part form whose actual size is 7-in. wide by 6-in. deep.

The control of the work request system centers around the mill maintenance foreman and his operating superintendent. The maintenance foreman originates the work requests for his department. The authority required for each job varies with the estimated labor as follows:

1. Routine repairs under five manhours—Maintenance department foreman.
2. Repairs from 5 to 150 manhours—Maintenance foreman and department superintendent.
3. Over 150 manhours—Department superintendent and superintendent of maintenance.

Larger jobs (above $1500) are handled as job requests and require management approval.

Five copies of the work request (Figure 2) are prepared by the originator and forwarded for the required approvals. After approval has been obtained, the scheduler in the central maintenance office assigns a work request number and makes distribution. One copy is sent to the accounting department to check the correctness of the cost code and then is forwarded by them to the tabulating department.

The next step, after providing a system for controlling the authorization of spending the maintenance dollar, was to insure correct reporting of how it was spent. Here again, the work request is the controlling factor. Since only the mill foreman and his assigned crews can charge direct to cost codes, everyone else must charge to a properly authorized work request number. Each man turns in a daily time distribution card which his foreman approves. These daily time cards are used as payroll cards. A clerk takes the time distribution off on tabulating cards and these provide the information used in daily cost control (Figure 3).

A daily report is sent to each mill foreman showing not only what jobs were worked on for him that day but how much time was charged and by whom. The mill foreman receives these reports within two or three days. This report also gives him distribution of his own manpower which was charged directly to his codes. It is issued on two pages, one, by work request number which goes to the mill foreman and the other by department number which goes to the craft foreman. A weekly report is sent out each Tuesday, showing all jobs worked on last week and their status to date.

Another weekly report, the manhour distribution report, (Figure 5) gives on a single sheet, the departmental breakdown to insure equitable distribution of the maintenance services as well as a check on the authorized forces.

The success of most systems depends on the amount of follow-up. In addition to the daily follow-up by intermediate supervision, a portion of our weekly supervisory meeting is devoted to discussion of costs. It has been found that the participation in this discussion, by individual foremen, is inversely proportional to the number of higher supervisors present. The livliest discussion takes place with only foremen present.

So much for the mechanics of the system. Does it pay? Are the foremen using it? The answer to both questions is yes. Some foremen are using it more than others.

In addition to the savings on maintenance costs, there are the added savings in the capital expenditure jobs, which the maintenance forces have performed. This is shown by the fact that Alan Wood labor in 1951 was able to do only 12 per cent of the capital expenditure jobs as against 22 per cent for 1953. In both cases, the largest jobs handled through outside engineering firms are excluded.

To claim that the daily cost control system should receive credit for all this reduction is erroneous. As in any cost reduction program, no one factor or group does it all. The issuance of prompt, accurate reports promotes active thinking and results in cooperative efforts for better and less costly work. The maintenance foremen appear anxious, now that they are getting cost figures, to use initiative and ingenuity to reduce the high cost items.

It may be of advantage to list some of the "Don'ts" in the application of this system.

1. Don't expect results of a permanent nature, after a staff organization has installed the system, unless it is followed up with active policing by every member of maintenance supervision.
2. Don't attempt to get every job on an individual work request. To avoid this we monthly blanket requests for small repetitive type jobs.
3. Don't issue too bulky a report. The daily summary with which we started was too bulky to re-

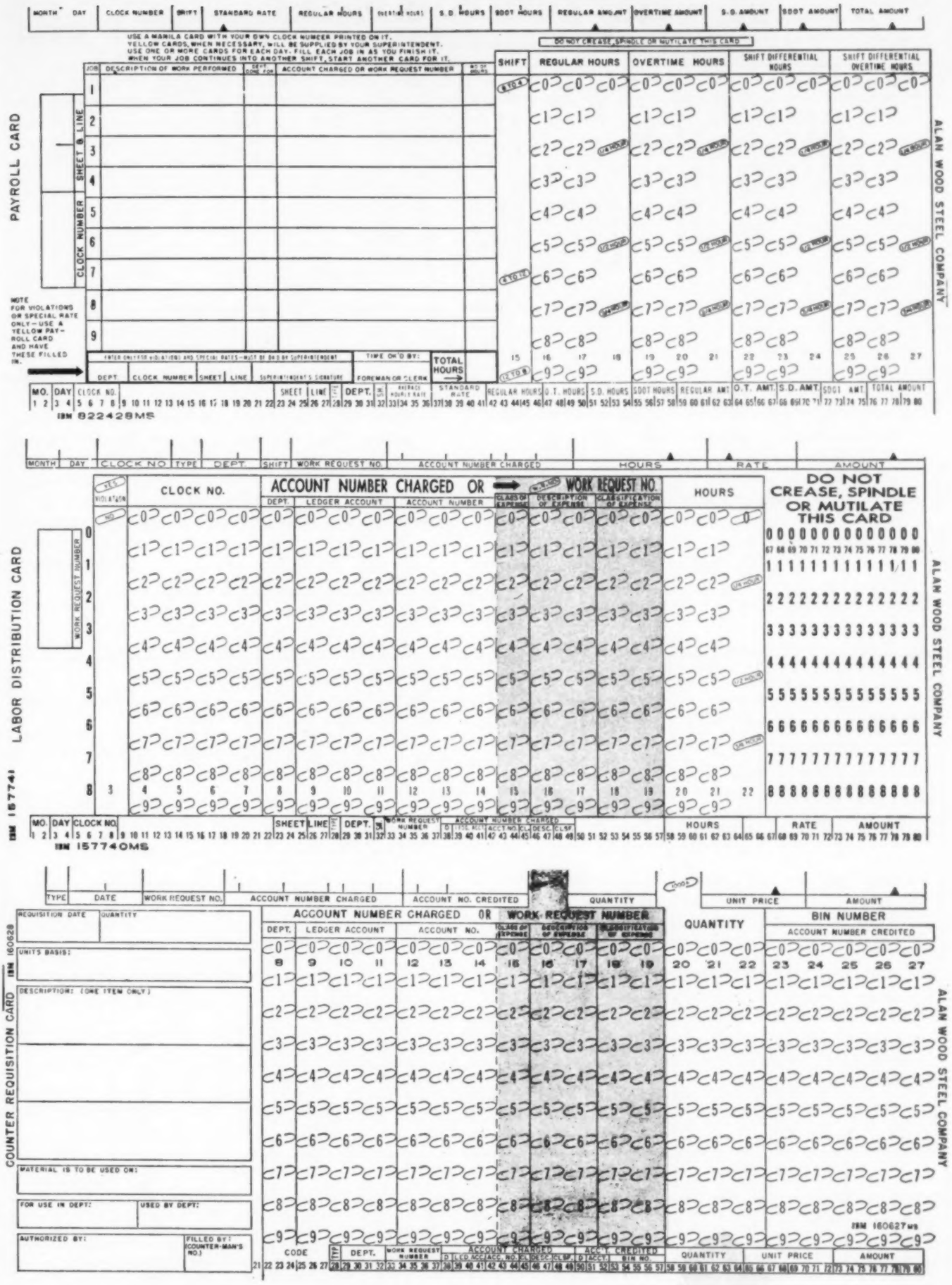


Figure 3 — The three tabulating cards form the basis of the system. On top is shown the payroll card. In the center, the labor distribution card, and on the bottom, the counter requisition card.

FORM S-M-43

DAILY MAINTENANCE CONTROL

DAILY COSTS BY WORK REQUEST OR ACCOUNT NO. (SHOWN FOR WHOLE HOURS OR DOLLARS)

ELEC SHOP

MONTH 3 DAY 25

WORK REQUEST NO.	DESCRIPTION OF JOB OR MILL MAINTENANCE CHARGE NUMBER	DEPT.	HOURS	AMOUNT	STORES MATERIAL	DIRECT MATERIAL	W. R. COMPLETE
63724	HOT RUN REP 4 MOTORS	630	16	34		5	
68120	CR 68 REP RESISTANCE	630	8	17			
95108	LOCO FUR OFFICE	630	11	23	11	10	
95136	WELD MACH PLUG	630	1	2			
99074	OVERHAUL LOCO 55	630	4	8			
	5 401 0124 21 00	630			4		
	5 401 0544 03 00	630			1		
	5 401 0544 15 00	630			24		
	5 401 5014 01 00	630			29		
			40	84	69	15	

Figure 4 — The daily maintenance control report shows time and stores charges.

view daily. Consequently the foremen did not use them.

4. Don't attempt to get too detailed an estimate on each job. This delays the summary report because the control copy does not get to tabulating.
5. Don't issue too many copies of the reports on costs. Nothing would cause the maintenance foremen to lose interest faster than to have these daily reports used against him by the "monday-morning quarterbacks."

APPENDIX

Upon completion of each work request, the maintenance department foreman writes the word *completed* and shows the date of completion on the No. 1 copy of the section. The scheduler then posts the date of completion to his No. 4 copy, after which he prepares a numerical list of completed work requests daily, signs it and sends it to the tabulating department. In the tabulating department the master card is punched completed for the work request number.

Figure 5 — The weekly manpower report gives by department all breakdowns on a single sheet.

WEEKLY MANPOWER REPORT

Date March 27, 1954 — Week Ending March 20, 1954

		Shop	Weld.	OSE	Rig.	Pipe	Hyd.	Carp.	Gen. Labor	Br. La. & LL	M. M.	R. C.	Hvy. Equip.	Lub.	Total	Job Req.
Department:		63 64-1	64-3	69	67-2	67-1	67-1	62	75	65-1 65-2	66-3 to 7 67-3&4	66-2	68	64-5		+= Over -= Under
Open Hearth	St'd. - All.	380 335	270 385	48 16	48 118	216 124	- —	352 342	1216 1118	1477 2257	1008 331	280 268	80 129	20 4	5395 5427	+ 32
Blooming Mill	St'd. All.	340 220	160 137	64 36	32 14	112 154	- -	32 42	108 144	24 32	496 526	480 381	- --	48 81	1896 1767	- 129
Plate Mill	St'd. All.	360 532	190 72	32 -	32 -	224 177	— -	32 --	108 179	24 46	536 496	424 323	10 31	40 45	2012 1903	- 109
S. M. Roll.	St'd. All.	300 784	190 359	48 32	32 24	96 136	- -	32 11	216 216	24 32	616 705	520 773	48 13	60 54	2182 3139	+ 957
S. M. Fin.	St'd. All.	180 93	80 11	32 --	32 -	32 8	- -	56 4	24 80	- -	320 356	60 82	20 12	36 10	872 656	- 216
Power Plant	St'd. All.	- -	- -	24 -	- -	24 --	-- -	-- -	- -	- -	48 102	- -	- -	8 -	104 102	- 2
U. M. & P.	St(d. All.	12 -	8 11	8 19	- -	8 11	- -	- -	-- 16	- --	- -	- -	575 491	- -	611 548	- 63
Gen. Plant & Misc.	St'd. All.	56 154	24 5	75 5	56 13	48 311	- -	32 67	108 32	24 14	- -	116 219	5 8	10 16	551 844	+ 293
Non-Oper. Depts	St'd. All.	12 62	12 6	32 16	16 18	24 43	- -	16 236	- -	16 16	664 360	48 60	40 76	- -	880 893	+ 13
Stores	St'd. All.	100 194	- -	- -	- -	-- -	- -	24 96	- 48	- -	- -	- -	- -	- -	124 338	+ 214
Job Requests	St'd. All.	500 138	100 210	152 214	268 218	320 106	— --	104 11	32 132	32 111	- -	80 155	30 179	- -	1618 1474	- 144
Totals	St'd. All	2240 2612	1034 1196	512 336	516 405	1104 1070	- -	680 809	1812 1965	1621 2058	3688 2878	2008 2261	808 939	222 210	16345 17091	+ 846

The tabulating department supplies each maintenance department workman with a pack of 25 IBM "payroll cards" which are prepunched for the clock number sheet and line, department and rate. These cards are also endprinted with the clock number and sheet and line for easy identification.

The packs of 25 payroll cards are distributed to the central maintenance office who in turn distributes them to the correct workman. The workmen use on an average one card per day, as spaces are provided thereon for nine different jobs. The spaces provide for the work request or ledger account number to be charged, with a space for the job description and hours used. Very seldom do the men do more than nine jobs per day. In each pack of 25 payroll cards, the 17th card has a yellow stripe across the top and does not have the corner cut. When this reaches the tabulating department, it automatically acts as a signal advising tabulating that a new pack of 25 cards should be prepunched and sent to the maintenance department for the individual involved. Therefore, there is no chance of a man running out of cards.

When a man works temporarily on another job at the same rate in a different department, he uses an IBM card, the same as the regular payroll card, except that it is not prepunched. When the tabulating department receives these cards they must key punch them instead of their being mark-sensed punched.

If he is on a temporary job at an up-graded wage, he uses a yellow payroll card which must be signed by a maintenance department superintendent; with this different color card it acts, of course, as a signal to everyone concerned.

Each day the workmen turn in their cards to their foreman for the work performed that day. The foreman checks the cards and initials them and then gives them to the central maintenance office where a few clerks reading the information on the payroll card mark-senses a "labor distribution card," for the clock number, the account number or work request number charged and the number of hours on each job. The clerk makes one labor distribution card for each line used on the payroll card—in other words for each job worked on. When all the labor distribution cards have been prepared for each of the crafts or sub-departments that day, a fly sheet is prepared by the clerk and sent with the labor distribution cards, segregated by crafts or groups, to the tabulating department.

The payroll cards made up originally by the workmen are sent to the timekeeping department where the hours worked are checked against the man's time clock card. Timekeeping then mark-senses the payroll card for shift regular hours, overtime hours, shift differential hours, and shift differential overtime hours. A fly sheet is then made by timekeeping and sent with the cards to the tabulating department.

In the tabulating department, the labor distribution cards are mark-sensed punched for the indicated information. They are gang-punched for month and day, type of card, etc. The cards are zero balanced for money and hours, and the daily maintenance control report is run for each sub-department. The labor distribution card and the counter requisition card from the stores department are combined by work request number or charge number and put on the daily maintenance control report. This counter requisition card is carried in a pack of 25 by the maintenance department foreman and no materials can be issued by the stores department to maintenance personnel unless they have a properly completed counter requisition card for each item withdrawn from the stores. Thus, it will be seen that there is complete control by tabulating cards of all time and materials used on any job.

As the daily maintenance control report is tabulated, a maintenance control summary card is automatically punched for each line on the report. These cards are accumulated until the end of the week, at which time they are merged with the previous to-date summary cards and with the master description cards which were punched originally at the time of receiving the work request copy in the tabulating department. This card shows the estimated hours to do the job. After this merging of cards, the weekly maintenance control report is issued, and a new to-date summary card is also punched automatically to complete the information for the next week's report. The summary cards are also available for use in preparing the monthly labor distribution reports for accounting purposes.

In addition to the daily and weekly maintenance control reports the tabulating department issues to maintenance a periodic list of all open work request, which is very valuable to the maintenance department foremen.

Summarizing the reports which tabulating prepares, we have first the daily maintenance control report, showing all daily costs and hours by each department or maintenance craft showing the work request or mill maintenance ledger account number. The weekly distribution of maintenance hours and costs shows the weekly total and accumulated totals to date compared to estimates. These two reports are the heart of the daily maintenance cost control program.

The work request, of course, is the backbone of the whole system and no jobs can be done by any maintenance personnel unless a properly completed work request has been issued to him.

DISCUSSION

PRESENTED BY

C. N. CODDING, Plant Engineer, United States Pipe and Foundry Co., Burlington, N. J.

W. B. CARTER, General Superintendent of Maintenance, Alan Wood Steel Co., Conshohocken, Pa.

C. N. Codding: I would like to know about what the ratio of maintenance manhours is to clerical manhours, to keep this system operating, or how many maintenance men per clerk are involved in this system.

W. B. Carter: In our maintenance organization we have a total of 400 men and 13 clerks. That is not the true story of the daily cost control system, because you have to count into it any addition that is necessary in the IBM system. It has been determined that no additional clerks were required in tabulating, added facilities include the latest model equipment.

PROGRAM

1954 AISE Convention

and

Iron and Steel Exposition

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

Tuesday, September 28

9:00 am—REGISTRATION—Main Lobby

9:15 am—BUSINESS MEETING—Ball Room

Conducted by President E. L. Anderson

9:30 am—ELECTRICAL SESSION—Ball Room

Chairmen: D. C. McCrady, Superintendent Electrical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada
Arthur B. Glover, Superintendent Electrical Div., Acme Steel Co., Chicago, Ill.

"Power and Control Cables for Steel Mills," by E. D. Youmans, Vice President in Charge of Research and Product Development, The Okonite Co., Passaic, N. J.

"Methods for Locating Faults on Electrical Cables," by Mount Fitzpatrick, Cable Plant Engineer, Duquesne Light Co., Pittsburgh, Pa.

"Communications in the Steel Industry," by T. E. Hughes, General Foreman, Electric Shops and Motor Rooms, Homestead District Works, United States Steel Corp., Munhall, Pa.

9:30 am—BLAST FURNACE SESSION—Club Room B

Chairmen: C. G. Hogberg, Assistant Chairman—Operating Committee, United States Steel Corp., Pittsburgh, Pa.
W. H. Collison, Assistant General Superintendent, Blast Furnace Div., Great Lakes Steel Corp., Ecorse, Mich.

"Rapid Method of Relining a Blast Furnace," by Bruno Vezzani, Works Engineer, Donora Steel and Wire Works, American Steel and Wire Div., United States Steel Corp., Donora, Pa.

"Developments in Extending Blast Furnace Stack Life After Appearance of Hot Spots," by R. W. Sundquist, Assistant Division Superintendent Blast Furnaces, United States Steel Corp., Gary, Ind.

"The Venturi Washer for Blast Furnace Gas," by J. E. Eberhardt, Division Head, and H. S. Graham, Engineer, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

2:00 pm—MECHANICAL SESSION—Club Room B

Chairmen: E. C. Hite, Assistant Superintendent Maintenance, The Timken Roller Bearing Co., Canton, Ohio.
C. W. Bruce, Chief Engineer, Republic Steel Corp., Chicago, Ill.

"Cooling Towers for Steel Plants — Why, When, Where and How," by Howard E. Degler, Technical Director, The Marley Co., Kansas City, Mo.

"Controlling Losses From Fire," by C. V. Batley, Insurance Surveyor, Bethlehem Steel Co., Bethlehem, Pa.

"Maintenance of Mobile Equipment," by Frank C. Wier, Superintendent Material Handling, and John C. Lantz, Maintenance Foreman, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

2:00 pm—COMBUSTION SESSION—Ballroom

Chairmen: E. H. Cauger, Assistant General Manager, Wheeling Steel Corp., Steubenville, Ohio.
H. W. Clark, Open Hearth Metallurgist, Ford Motor Co., Dearborn, Mich.

"Developments in Design of Modern Open Hearths," by Jay J. Seaver, Manager, Jay J. Seaver Engineers, Chicago, Ill.

"Some Aspects of Open Hearth Waste Gas Analysis Control," by F. P. Hubbell, Superintendent Fuel Dept., Homestead District Works, United States Steel Corp., Munhall, Pa.

"DSC's Multiple-Fueled Soaking Pits," by F. C. McGough, Superintendent of Fuel and Power, Detroit Steel Corp., Portsmouth, Ohio.

10:00 pm—PRESIDENT'S DANCE—Euclid Ball Room, Hotel Statler

Wednesday, September 29

9:00 am—ELECTRICAL SESSION—Ball Room

Chairmen: K. L. Johannsen, Division Superintendent Maintenance and Utilities, United States Steel Corp., Fairless Hills, Pa.
R. J. Beeswy, Electrical Superintendent, Inland Steel Co., East Chicago, Ind.

"Improvement in High Capacity Industrial Third Rail Systems," by H. Yale Mageoch, Chief Engineer, Electric Service Manufacturing Co., Philadelphia, Pa.

"Taper vs Straight Tread Crane Wheels," by J. A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Protective Devices on Ore and Coal Bridges," by S. Tatalovich, Electrical Engineer, Heyl and Patterson, Inc., Pittsburgh, Pa.

9:00 am—COMBUSTION SESSION—Club Room B

Chairmen: G. J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.
F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

"Rate of Heat Absorption of Steel. Furnace Performance Test Data Compared to Simplified Theoretical Calculations," by Fred S. Bloom, President, Bloom Engineering Co., Inc., Pittsburgh, Pa.

"A Continuous Batch Type Annealing Furnace," by Ralph H. Gelder, Works Metallurgist, and Walter E. Hand, Supervising Metallurgist, Ashland Works, Armco Steel Corp., Ashland, Ky.

"Applications of High Velocity Combustion to the Steel Industry," by Leonard C. Peskin, President, Thermal Research and Engineering Corp., Conshohocken, Pa.

2:00 pm—STEELMAKING SESSION—Ball Room

Chairmen: Robert Sergeson, Chief Metallurgical Engineer, Rotary Electric Steel Co., Detroit, Mich.
A. K. Blough, Superintendent No. 2 and 3 Melt Shops, Republic Steel Corp., Canton, Ohio.

"A New Way to Control Arc Furnaces," by Charles W. Vokac, Manager Hydro-Arc Furnace Div., Whiting Corp., Harvey, Ill.

"The Economic Aspects of the Oxygen Process," by W. C. Rueckel, Vice President, and J. W. Irvin, Associate Engineer, Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

"Ferro-Manganese Additions in Open Hearth Steelmaking," by Rudolph Tietig, Jr., Engineer, A. J. Boynton and Co., Chicago, Ill.

Exposition and Technical Sessions are at Cleveland Public Auditorium . . . . .

2:00 pm—LUBRICATION SESSION—Club Room B

Chairmen: N. I. Whiteley, Lubrication Engineer, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio.
W. M. Schuck, Lubrication Engineer, Armco Steel Corp., Middletown, Ohio.

"Non-Flammable Hydraulic Fluids as Applied to the Steel Industry," by C. R. Schmitt, Manager, National Lubrication Sales, E. F. Houghton and Co., Philadelphia, Pa.

"Stability of Lubricating Greases in Centralized Lubricating Systems," by E. L. Armstrong, Research Associate, and C. D. Thayer, Senior Technologist, Technical Service Dept., Socony-Vacuum Laboratories, Brooklyn, N. Y.

"What Type of Grease for that Application?" by W. A. Magie, II, Vice President, Magie Brothers Oil Co., Chicago, Ill.

6:00 pm—OLD TIMERS DINNER—The Hermit Club—1629 Dodge Court

Thursday, September 30

9:00 am—ELECTRICAL SESSION—Ball Room

Chairmen: Ray T. Winterringer, Assistant Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.
A. J. F. MacQueen, Electrical Superintendent, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada.

"Design and Construction of Transformers for the Steel Industry," by W. Walter Renberg, Jr., Electrical Power Design Engineer, Pennsylvania Transformer Co., Canonsburg, Pa.

"Kilovar, Kilowatt and Voltage Control in the Steel Plant," by L. G. Levoy, Industrial Power Engineer, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

"Synchronous Condensers for Steel Mill Service," by E. I. Pollard, Chief Electrical Engineer, Elliott Co., Ridgway, Pa.

9:00 am—LUBRICATION SESSION—Club Room B

Chairmen: C. T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio.
D. N. Evans, Assistant Master Mechanic, Inland Steel Co., East Chicago, Ind.

"Modern Techniques of Lubrication Applied to Old Mill Equipment," by E. G. Weimer, Superintendent Primary Mills Maintenance, United States Steel Corp., Youngstown, Ohio.

"Bearing Maintenance for Economy," by John A. Toth, Assistant General Manager, Bantam Bearings Div., The Torrington Co., South Bend, Ind.

"Antidotes for Sleeve Bearing Failures," by Anthony F. Kaminskas, Product and Field Engineer, Cleveland Graphite Bronze Co., Division of Clevite Corp., Cleveland, Ohio.

2:00 pm—PROTECTIVE COATING SESSION—Club Room B

Chairmen: D. E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.
J. B. Whitlock, General Maintenance Engineer, Armco Steel Corp., Middletown, Ohio.

"Maintenance Painting in the Steel Industry," by Cecil Schofield, Director of Laboratories, Process and Product Development Div., Republic Steel Corp., Cleveland, Ohio.

"The Use of Heavy Cutback Asphaltum Mastic Coatings in Coke Plant Areas," by A. H. Bagenstose, Jr., Eastern Regional Manager, Insul-Mastic Corp. of America, Pittsburgh, Pa.

"Color, The Second Value in Paint," by N. A. Mason, Manager Maintenance Paint Sales, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

2:00 pm—OPERATING PRACTICE SESSION—Ball Room

Chairmen: George I. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
S. O. Evans, Superintendent of Extrusion, Tubular Products Div., Babcock and Wilcox Co., Beaver Falls, Pa.

"Continuous Casting at Atlas Steels Ltd.," by John F. Black, Manager Continuous Casting Section, Koppers Co., Inc., Pittsburgh, Pa.

"Hot Skin Scarfing With a Mechanical Bloom Turner," by A. B. Glossbrenner, Assistant General Foreman, Bloom Conditioning Dept., Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

"Titanium: Its Progress and Its Applications," by T. E. Perry, Metallurgical Dept., and R. J. Garmy, Engineering Dept., Central Alloy District, Republic Steel Corp., Massillon, Ohio.

7:00 pm—FORMAL DINNER AND DANCE—Ball Rooms—Hotel Statler

Friday, October 1

9:00 am—ROLLING MILL SESSION—Ball Room

Chairmen: Alex Montgomery, Jr., Assistant to Vice President—Rolling, United States Steel Corp., Pittsburgh, Pa.
Wade Hoffman, Superintendent Roll Shop, Jones and Laughlin Steel Corp., Aliquippa, Pa.

"Cold Roll Forming," by Elmer J. Vanderploeg, Chief Engineer, The Yoder Co., Cleveland, Ohio.

"A-2 11-in. Rod Mill, Jones and Laughlin Steel Corp.," by N. A. Hansen, Superintendent, Rod and Wire Dept., Jones and Laughlin Steel Corp., Aliquippa, Pa.

"Causes of Roll Breakage," by Charles F. Peck, Jr., Assistant Professor, and F. T. Mavis, Professor and Head, Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

9:00 am—COMBUSTION SESSION—Club Room B

Chairmen: E. T. Mortson, Superintendent Power and Fuel, National Tube Div., United States Steel Corp., McKeesport, Pa.
R. A. Lambert, Superintendent Steam and Combustion, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"New Power, Steam and Blowing Installations at Ohio Steel Works," by J. P. Katzenmeyer, Project Engineer, United States Steel Corp., Youngstown, Ohio.

"A Power Plant Report to Management," by Stanley A. Nelson, Supervisor of Plant Engineering, Deere and Co., Moline, Ill.

"The Effect of Changes in Gas Composition on the Utilization of Fuel Gases," by Edwin X. Schmidt, Development Supervisor, Cutler-Hammer, Inc., Milwaukee, Wisc.

2:00 pm—ELECTRICAL SESSION—Ball Room

Chairmen: E. F. Donatic, Assistant General Superintendent, Service Div., Kaiser Steel Corp., Fontana, Calif.
R. T. Lucas, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.

"Operation of Magnetic Amplifier Controlled Tandem Mills," by J. W. Brinks, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., and J. C. Peth, Chief Electrical Engineer, Pittsburgh Steel Co., Monessen, Pa.

"Maintenance and Repair Experience with Various Hydraulic Systems on Charging Machines and Manipulators," by Robert S. Bogar, Assistant Chief Engineer, Bethlehem Steel Co., Johnstown, Pa.

"A New Design Concept for D-C Motors," by William R. Hough, Engineering Vice President, and R. A. Geuder, Manager, Industry Sales, Reliance Electric and Engineering Co., Cleveland, Ohio.

2:00 pm—OPERATING PRACTICE SESSION—Club Room B

Chairmen: Leonard Larson, Chief Engineer, Corrigan-McKinney Works, Republic Steel Corp., Cleveland, Ohio.
George H. Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

"Pinholes in Thin Steel and Pinhole Detecting Apparatus," by George H. Rendel, Research Associate, Research and Development Laboratory, United States Steel Corp., Pittsburgh, Pa.

"Continuous Drawing of Cold Finished Bars," by Walter J. Prochak, Assistant Superintendent, Cold Drawn Bar Dept., Youngstown Sheet and Tube Co., Youngstown, Ohio.

"Ten Years of Mechanical Descaling of Hot Rolled Steel Products," by Gilbert D. Dill, Engineer in Charge of Steel Div., American Wheelabrator and Equipment Corp., Mishawaka, Ind.

. . . Social Functions are at Hotel Statler . . .

Iron and Steel Exposition Hours

September 28—Tuesday, 10:00 am - 10:00 pm
September 29—Wednesday, 10:00 am - 10:00 pm
September 30—Thursday, 10:00 am - 5:30 pm
October 1—Friday, 10:00 am - 4:00 pm

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NO REGISTRATION FEE

IRON AND STEEL EXPOSITION

Cleveland Public Auditorium

September 28, 29, 30, October 1

LIST OF EXHIBITORS

1954 IRON AND STEEL EXPOSITION

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Arena.....Booth Nos. 200-399
North Hall.....Booth Nos. 400-500

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IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

ASSOCIATION of IRON and STEEL ENGINEERS

1010 EMPIRE BUILDING • PITTSBURGH 22, PA.

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ABSTRACTS of TECHNICAL PAPERS

to be presented at technical sessions of

AISE ANNUAL CONVENTION

CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

September 28, 29, 30, October 1

"POWER AND CONTROL CABLES FOR STEEL MILLS"

by E. D. YOUMANS, Vice President in Charge of Research and Product Development, The Okonite Co., Passaic, N. J.

E. D. YOUMANS

▲ ELECTRICAL equipment is an essential part of a steel mill. Its importance needs no emphasis. Service conditions vary greatly and may be severe, often including high temperature and corrosion problems. The best and most dependable wires and cables for the purpose are required to prevent costly power interruptions and shut-downs.

It is necessary to provide large amounts of power at various locations in the works, some of which may be at a considerable distance from the power house or substation. Most of such power is distributed to the point of use in the mill at higher voltages, i.e. above 5000 v. The engineer must decide whether to go underground or overhead.

Preferred practice in most steel mills is to install high-voltage power cables underground. While more costly than overhead construction, there are several advantages for underground installation including less susceptibility to damage by cranes, fire, lightning and wind storms and other causes. Underground cables are less likely to be an obstruction or occupy space needed for other purposes.

Oil impregnated paper-insulated, lead covered cables are generally used for high-voltage, underground power circuits. The lead sheath should have a corrosion protective covering preferably made with neoprene. Lower cost as compared with rubber insulated or varnished cambric insulated cables is an important advantage in favor of paper insulated cables. Non-leaded rubber insulated cables are often used where skilled splicers for lead covered cables are not readily available.

Bare or triple-braid weatherproof conductors installed on insulators are used on a large scale for high-voltage, overhead lines. This provides a low cost design. The great increase in the amount of electric power in steel mills in recent years has resulted in the installation of much more insulated, aerial cable than in the past. Space limitations, especially as the working voltages and number of such circuits have increased, are often reasons for the choice of insulated aerial cables. Dependability in case of storms and other emergencies, safety and appearance are additional considerations. Recent years have witnessed the development of a factory assembled design of rubber insulated, neoprene jacketed self-supporting aerial cable with these desirable features.

Non-shielded, oil-base, ozone resistant rubber insulated, neoprene jacketed cables provide a simple and dependable type for 2000 to 5000-v service which are easy to handle and install.

Rubber insulated, neoprene jacketed or braid covered wires and cables are recommended for power circuits up to 2000 volts and for control conductors. The large amount of d-c in steel mills makes it essential that the best quality rubber insulation be used to avoid trouble.

Thermoplastic insulated wires are used in locations involving severe exposure to oils and organic solvents.

Silicone rubber, a heat resistant, synthetic elastomer, is used for insulating conductors for service in hot locations. Cables made with this insulation are furnished with an aluminum sheath.

"METHODS FOR LOCATING FAULTS ON ELECTRICAL CABLES"

by MOUNT FITZPATRICK, Cable Plant Engineer, Duquesne Light Co., Pittsburgh, Pa.

▲ ELECTRICITY plays an important role in the operation of a modern steel mill. An interruption of power

to a strategically located item of equipment may result not only in down-time for the particular machine affected, but also in the idling of additional men and machines entailing an unwanted loss in productive capacity. Thus, the necessity for utilizing methods that will rapidly disclose the cause of power failure need hardly be emphasized.

MOUNT FITZPATRICK

The cause of power failure may frequently be isolated in a short time as when fuses are blown from overloading equipment or when electrical machines have failed internally. However, when a power failure has been attributed to breakdown of an electrical supply cable, the problem of locating the point of failure still remains, for in many instances it is economically unfeasible to provide for the indiscriminate replacement of electrical cables.

There are two basic schemes in general use for locating a point of breakdown on an electrical cable. The first mentioned scheme employs equipment that will measure the changed characteristics of a faulted cable. The second scheme imposes an electrical signal on a faulted cable which is used for tracing along the circuit until the point of failure is located.

The measurement schemes may be exemplified by various standard bridge methods that measure either the resistance or the capacitance of the cable to the point of failure. A recently introduced scheme utilizes the application of a short duration voltage pulse to a faulted cable and measurement of the time required for the reflection set up by the fault condition to return to the instrument. The use of measurement schemes usually requires a thorough knowledge of circuit constants.

The tracing schemes may impose an electrical signal of either voltage or of current. The voltage method applies a steep wave front of voltage to the cable which ares over at the fault, thereby producing an audible discharge. A detector unit is available which may be used to give a visual indication as to the location of the fault.

Tracing current methods may utilize an alternating current or a direct current. The current is interrupted to produce an easily identified signal and a detecting unit is used to ascertain the location of the fault by means of an audio or a visual indicator. The use of tracing schemes does not require a knowledge of circuit constants, but field exploration is required to locate a fault.

The successful application of either a measuring scheme or a tracing scheme in fault locating work is dependent upon a knowledge of the limitations imposed by the method selected. These limiting criteria are outlined for each scheme, in order that the final choice of method will locate the cable failure rapidly and accurately with a minimum of down-time for the equipment involved.

"COMMUNICATIONS IN THE STEEL INDUSTRY"

by T. E. HUGHES, General Foreman, Electric Shops and Motor Rooms, Homestead District Works, United States Steel Corp., Munhall, Pa.

T. E. HUGHES

▲FOR the purpose of this paper the author has divided steel mill communications into two broad categories. The first serves managerial and accounting functions, and is substantially point-to-point and private. This category includes telephone and teletype, both privately owned and leased, and office to office intercommunications. The second category embraces the individual production process at the workman level while the product is in process. This class includes the loud speaker systems, the FM power line carrier, and the mobile VHF radio.

No discussion of the first category is included except to note in passing that the status of this class is in no way impaired by the intrusion of the second. Rather, the two should combine to form a more integrated, useful tool for all concerned in the production of steel.

The author presents a brief history of the adoption of these communication devices at his plant along with examples of how each are used. Also included is a brief discussion of experience associated with their selection, installation and maintenance.

"RAPID METHOD OF RELINING A BLAST FURNACE"

By BRUNO VEZZANI, Works Engineer, Donora Steel and Wire Works, American Steel and Wire Div., United States Steel Corp., Donora, Pa.

BRUNO VEZZANI

▲ THE paper discusses the rapid relining of the No. 1 blast furnace of the American Steel and Wire Division at Donora, Pa. in July of 1953. This mantle-up relining was accomplished in 15 days, 9½ hours from blast-off to blast-on and entailed close planning and the cooperative efforts of all the various divisions that were involved.

A brief description of the early planning and the proposed repairs is given. The proposed methods of procedure and the preparations for the relining are described.

A day-by-day log and detail of the relining is given in outline form as well as a recapitulation of all the work performed either by contract or by the American Steel and Wire Division.

"DEVELOPMENTS IN EXTENDING BLAST FURNACE STACK LIFE AFTER APPEARANCE OF HOT SPOTS"

by R. W. SUNDQUIST, Assistant Division Superintendent Blast Furnaces, United States Steel Corp., Gary, Ind.

R. W. SUNDQUIST

▲ DURING 1951-53 an outbreak of a series of hot spots occurred on our blast furnaces, while there was sustained demand for maximum pig iron production, which forced development of methods to prolong the life of these stack linings.

Developments over this period evolved into the following four-point program:

1. *Detection of incipient hot spots*—Temperatures of the furnace shells are checked weekly by contact pyrometer. Temperatures of 200 F are regarded suspiciously and call for more frequent checks; while rising temperatures require closer inspection by core-drilling.

2. *Installation of shell sprays, augmented at times by insertion of a steam lance through a core-drill hole*—This serves to protect thin linings and promotes the build-up of a protective coating.

3. *Pumping grout inside furnace shell*—1¼ by 6-in. nipples with stop cocks are welded on the furnace shell in a pattern that will provide maximum coverage of the hot spot area. With the blast on, air-setting cement, mixed with water, is pumped into each of the nipples. This may be repeated for several days until the hot spot becomes dormant or until no more can be pumped. This is effective in filling voids behind the brick work and forming a protective coating on thin sections of brick.

4. *Installation of dovel type cooling plates*—Plates are used when other corrective measures have failed and a section of the original lining has completely disappeared. The outline of the area is determined by temperature gradients and small test holes burned in the shell. Openings are burned in the furnace shell; cast steel holders are welded in; copper dovel plates are driven into the holders; and, water connections are made to the plates. Rows of plates are staggered over the area with approximately 27 in. between centers horizontally and 18 in. vertically. The outer plates must be at the line of undisturbed brick to minimize future expansion of the hot spot. Shell sprays are then installed over this and adjacent areas. Finally, the area is grouted with the blast on to provide protection for the bare shell and to promote build-up between plates.

The results have been satisfactory. It has not always been possible to stop the expansion of the hot spot; however, some were contained for periods up to a year by sprays and grouting (Steps 2 and 3), and then the stack life was further prolonged by the installation of dovel plates. As the furnaces were raked out, a coating of grout and/or grout and deposits of burden was usually in evidence between the dovel plates. During the three year period, 1951-1953, nine stack linings were prolonged for an average of 13½ months with a maximum of 21 in two cases and a minimum of three. The additional tonnage of pig iron obtained justified the expense and effort involved.

In general, the furnaces operated reasonably well during the periods of prolonged life. They were not unduly rough nor uneven, and the tonnage and quality were close to normal expectations.

"THE VENTURI WASHER FOR BLAST FURNACE GAS"

by J. E. EBERHARDT, Division Head, and H. S. GRAHAM Engineer, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

J. E. EBERHARDT

▲ THIS paper presents results obtained with a pilot plant venturi gas washer with a nominal capacity of 25,000 cfm of gas and a plant scale venturi gas washer with a nominal capacity of 85,000 cfm of gas. The pilot plant data indicates that within the range of the data, the dirt content of the cleaned gas is dependent on the gas pressure loss across the venturi section; the range covered is from a dirt content of 0.09 grains per cu ft, at a pressure loss of 7 in. of water, to a dirt content of 0.015 grains per cu ft at a pressure loss of 24 in. of water. The gas pressure loss depends upon the gas flow rate and the water ratio (gallons of water per thousand cu ft of gas); and a correlation is presented.

H. S. GRAHAM

The water required for cleaning is approximately 5 gallons per thousand cu ft of gas, rather than upwards of 20 gallons per thousand cu ft of gas for conventional primary washers. The effect on the required size of thickeners is apparent.

No blockage occurred in either the venturi sections or the cooling towers during a year of operation of the pilot plant and nearly two years of operation of the plant scale unit. No wear or erosion of the venturi linings was detectable and no maintenance of the plant scale unit has been required.

"COOLING TOWERS FOR STEEL PLANTS—WHY, WHEN, WHERE AND HOW"

by HOWARD E. DEGLER, Technical Director, The Marley Co., Kansas City, Mo.

HOWARD E. DEGLER

▲ WATER is America's No. 1 natural resource. Water is big business recent federal, state and city conservation measures are cited. Stream and lake pollution problems are increasing. Many streams are overloaded resulting in temperatures too high for certain process work or condenser circulating water.

Selection of wet-bulb design temperatures, water cooling "range," and "approach" to wet-bulb are discussed as well as cooling tower application in steel and related industries.

Design factors are given for water-cooling equipment. Towers provide compactness, large capacity, flexibility, and all-around water-cooling performance for greater economy. Paper discusses various types of recent equipment from the modern horizontal packaged wood-filled type (5 gpm capacity) to high capacity double-flow induced draft units. Selection, performance, testing, operation and maintenance of water-cooling equipment are given.

Chemical advantages of cooling towers are discussed for plants on contaminated streams; considering that clean water leaves no corrosion or deposits, organic or mineral, in equipment serviced.

Curves show water-cooling tower performance vs approximate cost, as related to water gpm, cooling range and approach.

"CONTROLLING LOSSES FROM FIRE"

by C. V. BATLEY, Insurance Surveyor, Bethlehem Steel Co., Bethlehem, Pa.

C. V. BATLEY

▲ THE fire that destroyed a General Motors Plant about one year ago produced the largest single industrial fire loss on record. Large loss fires in single area buildings are increasing in the iron and steel industry. While General Motors is large enough to survive its loss, over 70 per cent of other firms who suffer a major fire loss fail within a few years.

The more important fire hazards in the iron and steel industry include congestion, considerable combustible construction in older plants, the presence of flammable oils and gases coupled with numerous large heat producers, the generation and use of electricity, and numerous spot hazards such as woodworking shops and coal tar by-product plants.

The iron and steel industry is carrying on programs to control these hazards. They vary in detail but, where successful, they fix authority and responsibility for the program on some specific person and have four fundamental features in common: (1) knowledge of the potential and possible fire hazards, (2) detection of the fire hazard, (3) selection of steps to correct or control the hazards, and (4) application of those selected steps.

Coordination between those responsible for fire protection and the various engineering, operating and maintenance groups has resulted in the elimination or control of many fire hazards.

Training programs for the employees have resulted in fewer fires and the extinguishment of most fires in the incipient stage.

Many locations have established well trained and well equipped fire departments.

In addition to automatic sprinklers for over-all protection, foam, water spray, foam spray, carbon dioxide and dry chemical systems protect special hazards.

In spite of these accomplishments losses are increasing. While industry engineers have cooperated, still more is needed of them. Their brains and ability are needed to work out solutions to some of the problems that are causing large losses, such as those occurring in large single area buildings. For years losses have been controlled by the physical division of values by fire stops and/or automatic protection. These appear impractical in many modern industrial buildings. What are the practical corrective steps?

"MAINTENANCE OF MOBILE EQUIPMENT"

By FRANK C. WIER, Superintendent Material Handling, and and JOHN C. LANTZ, Maintenance Foreman, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

FRANK C. WIER

▲ THE recent increased usage of mobile equipment has presented maintenance problems which are somewhat new to the industry. This is especially true where a material handling system has been integrated into a continuous production operation. The authors discuss maintenance methods designed to cope with these situations.

The first part of the paper describes the general structure and purpose of the maintenance system, which has been pin-pointed for flexibility. It draws a general picture of the organizational structure, maintenance policy, equipment operators relationship to maintenance, use of two-way radio, and the importance of adequate engine accessories.

Part two provides a detailed description of this equip-

ment maintenance program by delving into the actual physical aspects of the work place and its personnel, the handling of spare parts, work scheduling, servicing and control of pneumatic tires, promotion of safety and the desirability of good human relations.

JOHN C. LANTZ

"DEVELOPMENTS IN DESIGN OF MODERN OPEN HEARTHS"

by JAY J. SEAVER, Manager, Jay J. Seaver Engineers, Chicago, Ill.

JAY J. SEAVER

▲ THIS paper discusses the development of the modern open hearth furnace from the time of the earliest units. With developments in larger furnaces, the furnace charging floor has been gradually increased in height above the yard level. With these changes, the location of the regenerator changed from under the furnace to under the charging floor. Regenerator volume was increased through the use of outside secondary regenerators. The paper describes the different types of checkers and number of checker passes. It shows how the efficiency of the open hearth is limited by regenerator heating surface. In turn, the regenerator heating surface is limited by the solids from products of combustion. Thus efficiency can be increased by removing the solids, and the paper describes methods for removal of solids from the products of combustion and how these are disposed. It covers also, the distribution of the gases through the regenerator with details on how to streamline all gas flow to stop eddy currents, etc.

"SOME ASPECTS OF OPEN HEARTH WASTE GAS ANALYSIS CONTROL"

by F. P. HUBBELL, Superintendent Fuel Dept., Homestead District Works, United States Steel Corp., Munhall, Pa.

▲ A brief discussion is given of the equipment used and difficulties experienced with a trial waste gas analysis control installation on a 225-ton basic open hearth furnace.

A new design installation utilizing improved equipment is described. It is pointed out that an open hearth waste gas analysis control cannot give the type of control accuracy normally expected in the control of temperature, flow, pressure, etc. The factors affecting control ability at the various stages of an open hearth heat are briefly outlined.

F. P. HUBBELL

Combustion air flow records with and without the control in service are shown, and improved furnace roof life is reported during furnace campaigns with the control in service. Factors affecting open hearth furnace roof life and heat time are discussed and it is indicated that furnace refractory costs may be the major benefit possible from the use of a waste gas analysis control.

"DSC'S MULTIPLE-FUELED SOAKING PITS"

by F. C. McGOUGH, Superintendent of Fuel and Power, Detroit Steel Corp., Portsmouth, Ohio.

F. C. McGOUGH

▲ DETROIT Steel's new soaking pits are a part of a major rebuilding and expansion program undertaken by the corporation at its Portsmouth Division. This program included blast furnace, open hearth, blooming mill, and hot and cold strip mill facilities.

The soaking pit installation consists of multiple-fueled circular pits with metallic recuperation. The economic availability of plant-produced fuels dictated the utilization of either low Btu mixed gas or coke oven gas. This required the design and development of fuel systems that could effectively fire either of these gases, or No. 6 fuel oil on an emergency basis. Other factors that were considered were the rapid transfer of fuels so as not to adversely affect blooming mill production, and the uninterrupted supply of mixed gas during the periods of single blast furnace operation.

The operation of the pits is fully automatic. Special features include control equipment for a high thermal method of accelerated ingot heating.

Mill scale is utilized as a bottom material. The successful application of this "dry bottom" practice has resulted in a number of advantages.

"IMPROVEMENT IN HIGH CAPACITY INDUSTRIAL THIRD RAIL SYSTEMS"

by H. YALE MAGEOCH, Chief Engineer, Electric Service Manufacturing Co., Philadelphia, Pa.

▲ THE paper covers third rail systems for industrial applications from 300 to 1000 amperes capacity, with part

of the discussion covering the use of aluminum for the conductor member with associated components designed to produce an integrated type system having improved electrical characteristics, space saving features and reduced maintenance. The system, when used with suitable insulators, may be employed for voltages up to 4160 volts.

H. Y. MAGEOCH

The basic system may be converted into an enclosed or protected system by employing standard enclosure components. Some comment will be made on development testing and observations during test.

Other improvements in third rail systems will be shown in the form of a system employing fixed contacts with movable rail sections. This system represents a new idea in the field of current transfer methods for moving equipment and while different, it may offer the solution to problems now difficult to overcome. The system provides unobstructed space for movement of workers and equipment when ground level installation is required. The system also affords protection against electrical shock to workers by means of a special circuit interrupting design which deenergizes all unused contacts along the path that the moving equipment follows.

"TAPER vs STRAIGHT TREAD CRANE WHEELS"

by J. A. BELL, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

▲ THIS paper deals with a comparison of taper vs straight tread crane wheels, in which the writer illustrates the theory of his conclusions by the use of slides and motion pictures.

J. A. BELL

It is practically impossible to obtain accurate data through experiments on runways now in existence, since neither the crane nor the runway can be considered to be in perfect alignment, and it would be a waste of time to base conclusions on anything but an absolutely straight and level runway.

Therefore, the writer has had a working model of a crane constructed, using both taper and straight tread wheels, changing the wheels to obtain every conceivable operating condition, and with provision to adjust both the wheel spread and the span of the crane.

The writer covers buildings and runway conditions where straight tread wheels are to be recommended and also lists those building conditions where taper tread wheels will give the best wheel life, from a maintenance point of view.

There has been considerable data written in the past on the subject of taper treads, wherein claims were made that taper tread wheels will center the crane on the runway. Also, there has been the question as to whether or not taper treads cause weaving or skewing on the runway.

Both of these questions are thoroughly covered by the writer, and clearly illustrated by the motion pictures in slow motion.

"PROTECTIVE DEVICES ON ORE AND COAL BRIDGES"

by S. TATALOVICH, Electrical Engineer, Heyl and Patterson, Inc., Pittsburgh, Pa.

▲THIS paper is intended to familiarize those concerned with the various protective devices on ore and coal bridges and the importance of maintenance of these devices. It is not intended to show details of design but to generalize so that the function of all designs will be understood. Where details are given it is only a means of explaining the function.

S. TATALOVICH

The introduction briefly describes a typical bridge, pointing out its operational features which require special protection. First, a blanket statement that a bridge has all the usual protective devices found on all electrically driven cranes eliminates any discussion on these, and then the special features are taken one at a time and discussed in little detail with photographs of specific installations.

Among the special protective devices discussed are the anemometer, wind directional vane, rail clamps, skew limit switches, overspeed governor, trolley travel limit switches, trolley buffers, bridge buffers, skew indicator, and others.

The conclusion brings out the point that protective devices were developed due to users' experiences and that human inefficiency in operation and maintenance creates a need for more protective devices.

"RATE OF HEAT ABSORPTION OF STEEL. FURNACE PERFORMANCE TEST DATA COMPARED TO SIMPLIFIED THEORETICAL CALCULATIONS"

by FRED S. BLOOM, President, Bloom Engineering Co., Inc., Pittsburgh, Pa.

▲THE purpose of this paper is to present a simplified method by which the heating rate of steel billets and

slabs can be predicted with reasonable accuracy and without difficult, laborious calculations. The paper shows the relationship in two steps:

FRED S. BLOOM

1. The temperature distribution between surface and center temperature of a piece of steel while being heated within an industrial furnace.
2. The rate of heat transfer to a piece of steel under conditions of varying furnace temperature and varying steel surface temperature.

It is believed that if one factor is known, either furnace temperature or steel surface temperature, the other factor can be calculated so that the cause for poor furnace performance can be predicted and means taken to correct such conditions.

It is the hope of the author that a simple method of calculation can be used to predict the rate of heating of a slab or billet with reasonable accuracy and without long, detailed, theoretical calculations. In other words, the method of calculation to be presented is within the accuracy of a heat transfer investigation on an industrial level, such that the accuracy of prediction is well within the accuracy of a test investigation.

It is believed that furnace design establishes a heat pattern, which in turn establishes the rate of heating of a steel billet within a continuous furnace. Examples will be given to show why a furnace may be ideally suited for heating a steel billet of definite thickness, and not suited for material of larger section.

"A CONTINUOUS BATCH TYPE ANNEALING FURNACE"

by RALPH H. GELDER, Works Metallurgist, and WALTER E. HAND, Supervising Metallurgist, Ashland Works, Armco Steel Corp., Ashland, Ky.

RALPH H. GELDER

▲ THE Ashland, Kentucky, Works of Armco Steel Corp. has performed the bulk of its sheet and plate box annealing in continuous, car bottom, tunnel type annealing furnaces for approximately thirty years. The satisfaction experienced with this type of equipment thus led to the adoption of an improved model of such a furnace when increased tonnages of a specialty product, plates for the production of artillery cartridge case blanks, made an expansion of annealing facilities mandatory. The performance of this new furnace has been outstanding from the viewpoints of fuel economy, production rates, versatility and preciseness of temperature control.

WALTER E. HAND

The furnace is in the general shape of a tunnel, twelve feet in interior width, the bottom being formed by twelve insulated car bottoms, each 16 feet long. Sheets or plates to be annealed are loaded on a car bottom and covered with a light plate cover which rests in a sand seal around the outer edge of the car. As the loaded car is pushed into one end of the furnace by a pusher carried by the transfer lorry, an annealed load is discharged from the opposite end of the furnace. Interval between charges is fixed at such a period of time that proper temperatures are attained by the material in process for the desired type of anneal.

For purposes of firing and control of temperatures, the space between each side of each box cover and the corresponding furnace wall is considered as a unit control space. Through a series arrangement of control circuits, the firing on each of these units is governed by the temperature thermocouples placed in each end of the face of the charge and one thermocouple in combustion space between the furnace wall and the box cover. Temperatures exceeding respective set points at any thermocouple will result in reduction of fuel input to minimum to the entire controlled zone.

Results from operation of this furnace over a period of nearly two years have indicated a number of advantages over the principal alternative annealing method, the portable firing cover furnace. Important among these advantages are: economy of fuel, reduction in overhead crane service necessary, and uniformity of product quality resulting from temperature uniformity, both from one box load to another and from one position to another in each load.

"APPLICATIONS OF HIGH VELOCITY COMBUSTION TO THE STEEL INDUSTRY"

by LEONARD C. PESKIN, President, Thermal Research and Engineering Corp., Conshohocken, Pa.

LEONARD C. PESKIN

▲ THIS paper deals with the development of high velocity combustion for industrial applications and discusses the means of achieving such high velocity combustion. High heat release is given through the design of special industrial burners. The resulting products of combustion have special characteristics which are discussed in the paper. Because of the high velocity, peculiar aerodynamic as well as thermodynamic problems are created by this type of combustion. The burner has unusual convection heat transfer possibilities in comparison with heat transfer by radiation.

The high velocity combustion technique can be applied to many applications in the steel industry such as ladle heating, pre-heating of strip, edge heating of skelp, heating of gases, application to ore treatment, application to continuous barrel type furnaces and applications to recirculating radiant tubes.

"THE ECONOMIC ASPECTS OF THE OXYGEN PROCESS"

by W. C. RUECKEL, Vice President, and J. W. IRVIN, Associate Engineer, Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

W. C. RUECKEL

▲ IN normal manufacturing operations several questions arise concerning new processes, new developments, and new techniques. These questions deal with the economics of the process, with the technology of the process, and with the quality of the product in its effect on product marketability. From the standpoint of the oxygen converter, the latter two questions have been answered in recent trade journals and need no elaboration.

It is the purpose of this paper to investigate the comparative economics of the oxygen converter process. The cost studies presented are based on the experience of existing Austrian converter shops with due allowances for local conditions. In those cases where data is lacking, experience from bessemer converter plants was used as a basis of cost estimation. In the remainder of the cases, the knowledge of the requirements of the process as compared to an open hearth furnace was used to develop the cost figures.

J. W. IRVIN

Manufacturing costs are generally divided into two main groups; "costs above" and materials costs. One of the main items in "costs above" is fixed charges in which category the oxygen converter shows substantial savings over the open hearth furnace. It is shown that the oxygen converter installation can be made for about 40 per cent of the cost of an open hearth furnace, resulting in a production cost saving about $2.50 per ton. These capital savings result from the fact that not only is the basic equipment and auxiliaries lower in first cost, but the higher production rate of the oxygen converter (tons per hour) adds further savings. As the oxygen converter does not require an external source of heat, the fuel costs for the open hearth furnace are higher than the costs of purchased tonnage oxygen.

The material costs vary widely from day to day and also vary widely depending upon plant location. The raw material prices used in the cost study are shown so that proper adjustments can be made. In any event, the cost of metallics for an oxygen converter shop and for an open hearth shop are relatively close together, and the principal factor in the economic study lies in "cost above."

The economic importance of the oxygen converter process is so compelling that serious study of the process should be given by the steel industry when contemplating increased capacity or equipment replacement due to obsolescence.

"A NEW WAY TO CONTROL ARC FURNACES"

by CHARLES W. VOKAC, Manager Hydro-Arc Furnace Div., Whiting Corp., Harvey, Ill.

CHARLES W. VOKAC

▲THE electric-arc furnace is a significant part of our economy today. Its application appears to be boundless and increasing at an unparalleled rate. This progress is due to the cooperative, competitive, and ceaseless efforts of many industries, professions, and trades. Among them are the furnace builders who strive continuously to improve the arc-furnace equipment, reduce its costs, and improve its efficiency and operability. Thus, the arc furnace is made available for more new applications and becomes more competitive on existing processes.

A salient part of the arc furnace is the arc-furnace control. Perhaps most attention had been focused upon this part of the arc furnace and most effort, consequently, had been expended upon its development and improvement. This is quite natural. The arc furnace control is the business part of the furnace.

This paper, by a furnace builder, discusses various arc furnace controls from the earliest to the very latest available to-date. Particular emphasis is put upon the latter, since it is a fundamentally different type of control producing significantly different results. It provides the desired reciprocating electrode action without the use of the usual furnace regulator and without the use of reversing motors. It provides the electrode response and acceleration that is necessary to be compatible to the electrode speeds that are required today.

As a prelude, the paper discusses load, surge, and power factors in lay language. It discusses also, similarly, the negative arc characteristic and positive circuit characteristics, all in an effort to convey a better general understanding of the need for electrode responsiveness and rapid acceleration to make higher electrode speeds contributory toward better arc furnace regulation.

"FERRO-MANGANESE ADDITIONS IN OPEN HEARTH STEELMAKING"

by RUDOLPH TIETIG, JR., Engineer, A. J. Boynton and Co., Chicago, Ill.

RUDOLPH TIETIG, JR.

▲ THE paper describes the general design of a mechanism known as a ladle addition feeder and results from its use. This mechanism allows a considerably greater amount of manganese to be added to the ladle in open hearth steelmaking than is regarded practical by many operators. The basic design features that give this result are the ability to control the rate of making the addition and provisions for making the addition at the correct location in the ladle. Units incorporating these features have been installed in the recently constructed plant of the Lone Star Steel Company. Operating results at that plant are submitted. These results show the following advantages to be obtained from using the feeders compared with conventional open hearth practices:

1. Manganese consumption can be reduced because the yield from a ladle addition is greater than from a furnace addition.
2. Manganese additions can be calculated somewhat lower and not result in an increased number of missed heats on the low side.
3. The manganese spreads from ladle tests at first, middle and last ingots are reduced.

The advantages have a monetary value of $0.10 to $0.30 per ton of ingots depending on the grade of steel being produced.

The paper concludes with a brief statement of various adaptations of the basic design to plants other than the Lone Star Steel Company, including a unit that weighs the addition while it is being made.

"NON-FLAMMABLE HYDRAULIC FLUIDS AS APPLIED TO THE STEEL INDUSTRY"

by C. R. SCHMITT, Manager, National Lubrication Sales, E. F. Houghton and Co., Philadelphia, Pa.

C. R. SCHMITT

▲ NON-FLAMMABLE or fire resistant fluids for hydraulic usage have had a relatively short history in the industrial field. However, in recent years, more interest has been shown, generally, in this type of fluid by operators of hydraulic equipment than in any other single item.

Papers and talks given before various groups have dealt, principally, with the chemical and physical makeup of the available non-flammable fluids. It is the author's intention to emphasize the application data of such fluids covering as many practical aspects of their usage as possible.

There are many misconceptions about the nature of available fluids, both from the chemical standpoint as well as from that of actual usage in the machinery. Opinions which were formed a year or two ago, based upon experience, do not necessarily hold true today. It is the author's belief that many of the difficulties experienced with these new fluids have been caused by the popular attempt to associate them too closely with petroleum oils heretofore in general use.

This paper will describe basic differences between non-flammable hydraulic fluids and petroleum oils and will attempt to clear up misunderstandings as to the cause for some of the failures which have occurred in hydraulic equipment at the time of changeover from petroleum to non-flammable fluids.

Preparation of hydraulic machinery for the introduction of non-flammable fluids is a critical stage which may spell the difference between success or failure. Non-flammable fluids are synthetic in nature and have, also, excellent cleansing properties in the presence of oil sludges, oxidation residues, gums, varnishes, paints, rust preventives, and other normal or foreign materials found in hydraulic systems. It is necessary that these be removed as thoroughly as possible before installation of the fluid, otherwise premature contamination may occur. This can be done according to prescribed procedure available from the supplier of the fluid.

Another item which has a distinct bearing upon the success one has with performance of non-flammable fluids is careful removal of incompatible fluids which were formerly used. In general, it is essential to completely remove one non-flammable fluid if it is to be replaced by another of a different chemical makeup. Such incompatibility can result in chemical reaction and breakdown of the resultant mixture, and it is for this reason that the flushing procedure should be carried out very thoroughly.

Another important item to consider prior to installation of such a fluid is that of effect on seals and packings. Certain fluids have been found to adversely effect "O" rings, synthetic rubber seals and packings, and may leach out impregnation from leather packings.

Because of the difference in specific gravity, flow characteristics of the new non-flammable fluids are slightly different from that of petroleum oils. For this reason, it is essential to check the mechanical circuit to make certain that all pipes and fittings are tight and that packings and seals are in good condition so that air is not permitted to enter the system at the suction side of the pump. Cavitation, starvation and air leaks on the intake side have been responsible for most of the troubles encountered with non-flammable fluids. It is the author's opinion that proper understanding on the part of the user of the fluid and equipment and diligence on his part, insofar as the proper installation methods are concerned, will eliminate any difficulties attendant to the use of these new fluids.

In the steel industry, non-flammable fluids were at

first considered to be unnecessary due to the fact that flame and fire was a normal experience in the everyday production tempo of the mill. Statements were made that petroleum oils had been used in large quantities without serious fire hazards for years. With the advent of high pressure hydraulic systems, however, conditions changed and men in steel recognized fluid escaping from a break in the line under high pressure and velocity formed a combustible and explosive mixture which was very dangerous both to life and property.

Applications such as coke oven door openers, furnace mechanisms, hydraulic reels, unloaders, manipulators, dolomite machines, fuel mixing devices, etc., examples of equipment in which non-flammable fluids are being used in increasing volumes. The record of performance of non-flammable fluid in these applications has been on a par with hydraulic oils formerly used.

"STABILITY OF LUBRICATING GREASES IN CENTRALIZED LUBRICATING SYSTEMS"

by E. L. ARMSTRONG, Research Associate, and C. D. THAYER, Senior Technologist, Technical Service Dept., Socony-Vacuum Laboratories, Brooklyn, N. Y.

E. L. ARMSTRONG

▲ TO perform successfully in a centralized lubricating system, a grease must meet two requirements: (1) it must be the proper lubricant for the part to which it will be applied, and (2) it must resist separation into its two components—thickener and oil.

The first requirement may be summarized by stating that the speed, temperature, load, and design of the part will govern the selection of the lubricant. With respect to the second requirement, with which this paper is concerned, all greases will separate oil to a certain extent under conditions producing pressure filtration. In most centralized systems, the seal between the moving parts depends on small clearances between these parts. These clearances act as filters to collect solid or semi-solid materials. Hence the design of the lubricating system affects the tendency of the grease to separate. Such separation leaves residues of thickener, or thickener concentrates, which are liable to clog the metering device of the lubricator. This may cause the lubricator to function erratically or not at all. However, if the amount and frequency of application of the grease are great enough, objectionable residues will be flushed away as they form.

C. D. THAYER

Another cause of lubricator clogging is outside contamination of the grease. This is a matter of proper care and handling of the grease and has nothing to do with grease characteristics.

All greases do not have the same resistance to separation. To compare greases on this point, the S/V separability test was devised. A sample of grease is held on a porous plate and subjected to pressure, and the amount of oil forced from the grease and the rate at which it emerges are measured. Greases which have formed thickener deposits in centralized lubricating systems in the field have been found to separate more oil, at a faster rate, in this test than greases for which no troubles are reported. This indicates that the test is a useful screening device for greases to be used in centralized lubricating systems.

Typical curves showing rate and amount of oil separation are presented for greases which are good and bad in this respect. Data are also included which show the effect of type and amount of thickener, and viscosity of mineral oil on this characteristic of the grease.

"WHAT TYPE OF GREASE FOR THAT APPLICATION?"

by W. A. MAGIE, II, Vice President, Magie Brothers Oil Co., Chicago, Ill.

W. A. MAGIE, II

▲ PERFORMANCE, simplification, and cost are the author's three most important considerations in selecting the proper type of grease for each steel mill application. No particular type of grease is favored—such as calcium, sodium, lithium, barium or bentone, nor is it felt that an all purpose or multi-purpose grease for steel mills is yet practical or economical.

Several laboratory performance tests rather than straight physical or chemical tests of the different grease base types are reviewed. Plasticity characteristics at elevated temperatures are felt to affect the field performance of each type of grease in respect to bearing retention rather than drop points. The author refers to the accepted belief that the grease is not much better than the oil in it, so that with petroleum oils regardless of the drop point of the product or type of soap from which it is made a safe operating temperature is close to 200 F. It is pointed out that in rolling mill operations the grease must have good wear characteristics as well as the ability to withstand extreme pressure. Non-soap type greases do not make economical extreme pressure lubricants based on the author's own manufacturing experience.

Four distinct soap type of greases are suggested to properly cover the solid lubricant requirements in steel mills with winter and summer grades in each case. We have all weather or multi-grade motor oils but to date the use of high viscosity index oils and viscosity index

improvers in grease has not accomplished the same end result. Any thermoplastic material such as grease is affected by temperature changes in degrees of plasticity or body against an oil in degrees of viscosity. Further research is urged to develop all weather greases so that we can have good pumpability at low temperatures with small changes in plasticity or body at high temperatures and still maintain the superior characteristics of a grease that will adhere, withstand pressure, and inhibit rust.

"DESIGN AND CONSTRUCTION OF TRANSFORMERS FOR THE STEEL INDUSTRY"

by W. WALTER RENBERG, JR., Electrical Power Design Engineer, Pennsylvania Transformer Co., Canonsburg, Pa.

W. W. RENBERG, JR.

▲IT would be impossible to build power transformers without steel and not many products depend upon steel to such an extent as the modern transformer. Basically, transformers consist of two current-carrying coils, linked magnetically, so that power may be applied at one voltage and utilized at another. The core, made of electrical sheet steel, provides the necessary magnetic linkage. Furthermore, steel is essential for the internal supporting structure and for the tank shell.

However, there is another side of the picture. While transformer manufacturers are greatly indebted to the steel industry, the modern highly-electrified steel mill could not exist without transformers. Power supply transformers step down the utility transmission voltage to the plant distribution voltage. Furnace transformers supply power at low voltages and high currents to the electric furnaces. Load-center transformers step down the plant distribution voltage to the utilization voltage at the load.

In discussing transformer design, five basic circuits are important. These are the electric circuit (coils), the magnetic circuit (core), the dielectric circuit (insulation), the thermal circuit (cooling equipment) and the mechanical circuit (supporting structure).

Reliable performance and low operating costs are important considerations in power supply transformers. Improved quality of electrical sheet steel has resulted in smaller cores and lower losses. Since the coils of the electric circuit surround the core legs, less copper is required, leading to lower copper loss. The dielectric circuit must withstand surges due to lightning or switching. Heat generated in the core and windings is dissipated by external radiators, and fans are often mounted below the radiators to provide increased capacity. Liberal cooling ducts insure against winding hot spots, which may lead to costly power failures. Precompressed coil stacks and adequately designed supporting structures prevent short circuit damage.

The electric circuit of furnace transformers is complicated by the requirement for power at low voltages and high currents. Secondary windings require few turns, but a large cross-sectional area is necessary. A number of winding sections are provided, and connected in parallel. Careful design is required to insure equal load distribution among these sections. The magnetic circuit is utilized to provide the secondary tap range required during the melting and refining period. Constant primary voltage is applied to a variable number of turns in the primary winding, thus varying the flux density in the core and giving a range of secondary voltages. Repeated interruptions of the load circuit to permit tap changes cause switching surges, and adequate margins must be provided in the dielectric circuit. Repeated short circuits occur during the melting process and the resulting forces require a well-balanced design and adequate bracing. The transformers are usually water-cooled, since water is required for cooling the furnace electrode holders.

The load-center substation avoids the voltage drops and losses associated with long runs of low voltage bus. The transformers differ from those already discussed in the dielectric and thermal circuits used. To avoid the fire hazards of oil-filled units, either "askarel" or "dry-type" transformers are used in many load centers. In the "dry-type" units natural or forced circulation of air through the cooling ducts may be used or a nitrogen-filled, sealed tank unit may be provided. The higher operating temperatures require the use of inorganic insulation. Sealed silicone insulated units offer an advantage in steel mills since the interior of the transformers is protected from the contaminated atmosphere.

This paper presents a few of the problems encountered in the design of transformers for the steel industry. It is felt that an understanding of these problems should assist steel company engineers in specifying transformers best suited to individual requirements.

"KILOVAR, KILOWATT AND VOLTAGE CONTROL IN THE STEEL PLANT"

by L. G. LEVOY, Industrial Power Engineer, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

L. G. LEVOY

▲ THIS paper outlines the importance of kilovar, kilowatt, and voltage control and explains the fundamental considerations for the control of these quantities.

The problems and methods of control differ depending upon the mode of operation of the plant. The following three modes of operation are considered:

1. Plants which generate all of their own electric power.

2. Plants which generate part of their electric power and purchase part from the utility.
3. Plants which purchase all of their electric power from the utility.

The basic problems of kilovar, kilowatt, and voltage control are explained for each of these cases.

"SYNCHRONOUS CONDENSERS FOR STEEL MILL SERVICE"

by E. I. POLLARD, Chief Electrical Engineer, Elliott Co., Ridgway, Pa.

E. I. POLLARD

▲THE synchronous condenser has been practically superseded by the static capacitor as a means of powerfactor correction, where only steady state condenser capacity is of primary importance, for reasons of both initial cost and cost of operation. However, the synchronous condenser has marked advantages over the capacitor for transient and subtransient operation during rapid load changes.

A dip in voltage at the condenser terminals due to load increase causes it to feed more capacitive kva into the system thus diminishing the magnitude of the voltage dip. On the other hand, a dip in voltage at the terminals of a shunt static capacitor causes it to feed less kva into the system and increases the magnitude of the voltage dip. Thus a synchronous condenser assists in smoothing out system voltage fluctuations while a capacitor magnifies the fluctuations.

The arc furnace is subject to frequent and severe short circuits during the melting-down period. It is therefore a particularly difficult load to handle from the standpoint of maintaining reasonably steady voltage in the steel mill and nearby portions of the power system. A synchronous condenser connected to the furnace bus is a convenient means of controlling these voltage fluctuations and at the same time correcting power factor.

Addition of a buffer reactor between the furnace bus and the system increases the effectiveness of the condenser in reducing voltage fluctuations on the power system. Further addition of a capacitor in series with the condenser, between the condenser and the furnace bus, enhances still further the effectiveness of the condenser in minimizing voltage fluctuations on the system. Curves are presented indicating the improvement in voltage fluctuations as a function of condenser size with and without a buffer reactor and series capacitor, for a typical installation.

A condenser of special design with lower than standard subtransient and transient reactances should be considered for this service. This and other desirable electrical characteristics and design features of condensers for arc furnace application are discussed. Advantages and disadvantages of hydrogen-cooled condensers are considered.

"MODERN TECHNIQUES OF LUBRICATION APPLIED TO OLD MILL EQUIPMENT"

by E. G. WEIMER, Superintendent Primary Mills Maintenance, United States Steel Corp., Youngstown, Ohio.

E. G. WEIMER

▲THE author has written this paper from the point of view of the maintenance organization of a plant, which is endowed with two old primary mill units. He points out that old equipment needs minor redesign to provide for application of modern lubrication techniques and equipment. He then reviews the method of attack used to improve maintenance cost and reduce delays on these mills.

The paper covers such items as materials and lubricants used on table lineshaft bearings, bearings of table rollers, mill pinions and bearings, etc. Some highlights of the paper are the description of a novel spray lubricating method applied to roll neck bearings of the reversing mill, the description of revisions in construction of mill pinion housings to provide for modern pinions and lubricants, and the problems faced in education of old time millwrights. The paper is illustrated with slides covering the primary points of interest.

"BEARING MAINTENANCE FOR ECONOMY"

by JOHN A. TOTH, Assistant General Manager, Bantam Bearings Div., The Torrington Co., South Bend, Ind.

JOHN A. TOTH

▲STEEL mill operations can no longer neglect to recognize the progress that has been made in anti-friction bearing engineering development and manufacturing. Industry is now faced with the problem of lower unit cost. This cost may be controlled in many ways, but the application and maintenance of anti-friction bearings in steel mill equipment is very important because of the capital investment involved.

Economy can only be related to bearing applications when continuous operation or performance for maximum service life expectancy is obtained from the bearing. From an engineering point of view, the many types of anti-friction bearings can be designed in proportions to meet the condition of loads which may be primarily radial or thrust. In many instances, limitations are in-

troduced because of the available space. The selection for the bearing can be carefully made not only by mathematical analysis, but particularly based on actual service life experience.

To make a life prediction for anti-friction bearings, it is necessary to evaluate the conditions of operation in terms of their effect upon the bearings. Many factors which enter into this problem are: load, speed, conditions of smooth or shock operation, corrosion influences, accuracy of members adjacent to the bearing, temperature, and particularly lubrication. These factors may be easily formulated in many cases, while others present greater difficulties. Frequently the presence of errors in assessing these values causes considerable disagreement between the computed and actual life of a bearing installation. It is at this stage that proper engineering analysis and experience is mandatory in the proper selection of bearing types and sizes.

It is possible to predict with surprising accuracy the average life of a group of bearings. This permits the application of the law of averages. Obviously, the larger the group, the more accurate will be the prediction. Statistical data taken from actual laboratory tests, as well as service experience with anti-friction bearings, indicates that an approximate 10 per cent of the bearings in a group are not predictable for life expectancy.

Abnormal load conditions and improper fitting practice will very rapidly reduce the bearing service life. A condition of misalignment in the application will not permit the applied load to be carried by the whole bearing so that related increased stresses on the bearing elements will introduce premature fatigue and ultimate failure.

Basically, lubrication has been established as a critical factor for good bearing performance. The use of heavy consistency lubricants is not desirable because of the possibility of channeling. The lighter consistency lubricants such as semi-fluid greases, oils, and oil-mist lubrication assure good bearing performance.

These brief factors are indicative of the attention necessary to guarantee good bearing performance for economy.

"ANTIDOTES FOR SLEEVE BEARING FAILURES"

by ANTHONY F. KAMINSKAS, Product and Field Engineer, Cleveland Graphite Bronze Co., Division of Clevite Corp., Cleveland, Ohio.

▲THE paper carries a short introduction to sleeve bearings with a brief dissertation outlining the important chronological contributions and advancements made by the sleeve bearing industries.

ANTHONY F. KAMINSKAS

Design to prevent bearing failure — Bearing design techniques are briefly outlined with a few remarks about the various conditions investigated before a set of recommendations are finally set. Factors such as bearing crush, bore distortions, clearances, operating temperature, bearing alloys, and housing materials are mentioned and how each in itself constitutes a separate study in the design of a sleeve bearing.

Bearing failures—The last part of the paper dwells particularly on typical sleeve bearing construction with the main emphasis of this part of the paper devoted to sleeve bearing failures. A discussion accompanies each illustration covering typical sleeve bearing failures with special emphasis on the following:

1. Fatigue failures.
2. Wiping and seizure failures.
3. Corrosion failures.
4. Wear and scoring failures.
5. Erosion failures.

Principal factors contributing to the failures are discussed and what must be done to prevent reoccurrence of such failures.

Conclusion—In the conclusion are found a few comments about what can be expected in the way of bearing life and illustrations of bearings which have performed satisfactorily.

"MAINTENANCE PAINTING IN THE STEEL INDUSTRY"

by CECIL SCHOFIELD, Director of Laboratories, Process and Product Development Div., Republic Steel Corp., Cleveland, Ohio.

CECIL SCHOFIELD

▲THE iron and steel industry has two general maintenance paint problems: coating of new work and repainting of existing structures. For new structures three coats of paint are needed: primer, intermediate and final coat. The surface must be thoroughly cleaned of rust, grease, loose scale and other contaminants before applying the primer. Surface treatment used may be either mechanical, e.g., sand blasting, flame cleaning, wire brushing; or chemical, e.g., an inhibited acid wash followed by a water rinse. Isolated areas of tightly adherent mill scale may need spot repainting after exposure, or this scale may be removed by allowing a weathering period of approximately six months before painting. Wetting oils which penetrate into the pores of the rust may be used when it is impossible to remove all rust. These are always followed by the usual three coats. Repaint work requires removal of all loosely adherent paint, and acid wash treatment of all rust areas.

New paint may fail due to moisture, sunshine, atmospheric fumes, poor preparation of metal surface, as well as the use of wrong primer. Repaint failure is usually due to incompatibility of new paint with old, or poorly prepared surface. Paint failure is indicated by blistering, peeling, wrinkling, scaling, crawling and chalking.

Paint should be purchased by performance rather than formula specification. Development of one's own paint formula requires formation of a new department and employment of highly trained paint chemists; relieves the manufacturer of any responsibility in case of paint failure; prevents taking advantage of the knowledge of paint chemists employed by manufacturers and of advances which they make. Performance specification, however, permits change with each new advance and acts as a stimulus to research. The supplier should be given all atmospheric and other pertinent information when performance specifications are made.

The control laboratory should consist of two sections: performance and material control. The performance section should have a weatherometer to determine fading, chalking, etc.; water immersion tank to check permeability of coating films; salt spray tank to obtain fast breakdown; humidity tank; and outdoor exposure rack for long term checking. Laboratory results thus obtained give only an indication of performance, not actual service life. The material control section requires a weight per gallon cup, centrifuge for determining pigment and vehicle percentages, viscosity cup, hiding power charts, scales for weighing and miscellaneous analytical equipment. With such a laboratory, the personnel can predetermine the basic type of paint which will wear best under particular conditions.

"THE USE OF HEAVY CUTBACK ASPHALTUM MASTIC COATINGS IN COKE PLANT AREAS"

by A. H. BAGENSTOSE, JR., Eastern Regional Manager, Insul-Mastic Corp. of America, Pittsburgh, Pa.

A. H. BAGENSTOSE, JR.

▲ABOUT eight years ago, a major steel company began to use a heavy cutback asphaltum mastic protective coating to protect structural steel, steel tanks, vessels and gas mains in their largest coke plant with excellent results. Since that time, the use of asphaltum heavy coatings has spread throughout coke by-product industries so that most coke plants have applications of this type in service today and the use of mastics is still expanding.

A successful protective coating application depends upon three primary important conditions:

1. Proper material considering both type and quality.
2. Proper surface preparation.
3. Proper application.

No paint or coating is a cure-all. Each type of coating has its advantages and disadvantages. No coating should be specified for an area where the conditions exceed its limitations, for only failure can result. After the proper type of coating has been selected, evaluation of materials in that group should be made to determine those most suitable. There are many various grades, combinations and viscosities of asphaltum mastic coatings on the market today. Good asphaltum coatings should have the following properties or characteristics:

1. Resistance to outside weathering and heavy chemical atmospheres.
2. Good adhesion.
3. Flexibility or ductility.
4. Wide temperature tolerance.
5. Low moisture vapor transmission.
6. Uniform viscosity and freedom from lumps, foreign matter and tendency for fillers to settle out.
7. Fire resistance.
8. Low shrinkage.
9. Resistance to abrasion and impact.

For accelerated evaluation of above properties, there are numerous laboratory tests that can be made.

Proper surface preparation before the application of any protective coating cannot be over-emphasized if long life is expected. No paint or coating will last long when applied over rust, scale, dust, oil, loose paint or moisture. Where permissible, there is no better cleaning method than sand-blasting, for it is the most thorough and most economical method for the results obtained.

There is a saying that a protective coating is no better than the man who applies it. The application should be performed according to the manufacturer's recommendation by trained workmen in a craftsmanlike manner or failure may result. To obtain a good coating, the mastic must be applied as uniformly and as smoothly as possible. A recent innovation of hot spraying of cold asphalt coatings has proven to be of great assistance in obtaining good applications.

"COLOR, THE SECOND VALUE IN PAINT"

by N. A. MASON, Manager, Maintenance Paint Sales, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

N. A. MASON

▲ THE National Paint, Varnish and Lacquer Association advertised the protective value of paint in their slogan, "Save the surface and you save all." This slogan has been used by all members of the association for a number of years, and today paint is generally considered to be a protective coating.

A limited number of paint manufacturers began the promotion of color in paint in 1925. This promotion was directed to manufacturers of equipment requiring paint as a protective coating. Color was used to create sales appeal in this instance and has continued through the years.

About fifteen years ago color was promoted in the hospital field as a mild therapy. The medical people were receptive to the promotion, and a number of tests were conducted. These early experiments are a matter

of record and established color as an aid in the treatment of people confined to hospitals and other medical institutions.

In 1940, when America was busy arming their allies against their oppressors, one or two paint manufacturers reasoned that if color could assist the medical men in treating sick people, why not promote its use to industry as an environmental factor for people busy at a task within a restricted area. The old Curtis-Wright plant at Buffalo, N. Y., was one of the first plants painted according to a predetermined color system developed by a paint manufacturer. This application of color in industry established color as the second value in a can of paint.

The basic thinking behind the selection of color for this project that pioneered one of America's best known color systems for industrial application, was increased production and human efficiency. People generally feel much better on a bright, pleasant day than they do when the day is overcast and gloomy. Therefore, color for appearance was considered to be a starting point for planning a color system. Another factor was seeing conditions within the plant proper. Could a visual task be executed without eye strain or nervous tension? Most plants engaged in war production were about as cheerful and bright as a hole in the ground. Naturally, those responsible for production listened to the color story and in many instances were willing to try it in some restricted area. Many of these trial jobs, of minor importance to the paint manufacturers as related to the quantity of paint used, mushroomed into major painting projects. Workers in unpainted areas began to ask for transfers to areas where color was applied to machinery, equipment, walls and ceilings. Production in the newly painted areas increased 10, 20, and in some cases, 40 per cent.

"CONTINUOUS CASTING AT ATLAS STEELS LTD."

by JOHN F. BLACK, Manager Continuous Casting Section, Koppers Co., Inc., Pittsburgh, Pa.

JOHN F. BLACK

▲ THIS paper is of interest to steel mill operators and engineers everywhere because it describes the first commercial installation of a continuous casting machine for steel on this continent. A moving picture will also show actual operation of the machine which seems destined to at last take its place in the forward development in the art of steelmaking.

The equipment can function as an auxiliary in the large steel plant. It is no longer limited by casting sizes, and present techniques make it a feasible and proven matter in casting large slabs. Similar techniques and improvements in cooling facilities make the machine an instrument for high speed casting of billets down to two inches square.

It provides for the small producer, flexible billet making capacity at relatively low capital cost and moderate operating expense. It is equally adaptable to the casting of carbon or alloy steels over a wide range of analyses, and the process covers almost unlimited possibilities in the modern steel mill.

"HOT SKIN SCARFING WITH A MECHANICAL BLOOM TURNER"

by A. B. GLOSSBRENNER, Assistant General Foreman, Bloom Conditioning Dept., Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

A. B. GLOSSBRENNER

▲SIXTY-FIVE per cent of bloom conditioning at Timken is skin scarfing. With the trend toward an even larger percentage of total tonnage being skin scarfed, the need for a method of increasing tons per man-hour along with a more efficient handling system became quite evident. We feel that this desire has been pretty well met or a solution at least indicated by the recent installation of our new hot scarfing setup.

By far the most interesting comment about our new scarfing method has been the result obtained. Manpower was reduced about 50 per cent and production for this particular scarfing operation was increased by two-thirds.

Formerly, a scarfer and a helper were required at each scarfing station. The helper was necessary to aid in turning the blooms and cleaning slag. A small overhead crane moved the steel (6 x 6, 9½ x 9½, 11 x 13, 13 x 15) from a preheat furnace to the individual beds and helped turn the larger blooms. The building was low and narrow.

The reduction in manpower was accomplished by the design and installation of a simple mechanical bloom turner. Scarfing slag was made more easy to handle by the conversion of the crane to floor control operation. The roof was raised and the building expanded slightly to allow an 18,000-lb capacity lift truck to move steel from the heating furnace to the turning machines. One helper for the entire operation proved sufficient to keep steel moving and slag cleaned up.

The scarfing torch was replaced by a larger torch to permit faster metal removal in fewer passes to a bloom with completely satisfactory results. A study was then made and an incentive rate set. These two features plus the greater flexibility and elimination of handling bottle-necks achieved by the use of a lift truck account for the increased production.

Results for the first six months of operation have been better than anticipated and show every sign of continuing.

"TITANIUM: ITS PROGRESS AND ITS APPLICATIONS"

by T. E. PERRY, Metallurgical Dept., and R. J. GARMY, Engineering Dept., Central Alloy District, Republic Steel Corp., Massillon, Ohio.

T. E. PERRY

▲WITHIN the last year, the technology of titanium has made rapid advances. Developments in basic extraction, melting, processing and fabrication have been significant. New alloys have been developed which are weldable and which are heat treatable to as high as 200,000 psi ultimate strength with good remaining ductility. Parameters of usefulness are becoming better defined with increased usage and improved product quality. Industrial growth of titanium is based largely on four principal characteristics of this metal: availability of plentiful domestic ore reserves, its light weight, high strength and corrosion resistance.

R. J. GARMY

Titanium is playing an increasingly large role in swinging the balance of power in the air in favor of the United States. A major part of all titanium produced is serving in this capacity. Adaptability of titanium to ordnance equipment may govern to a large extent not only the striking power, but the ability to deliver tomorrow's air-dropped armies. In non-military applications, such as chemical plant and food processing equipment, titanium is already paying its way—some times in a spectacular manner, as a corrosion resisting structural metal. It is being used with remarkable success as orthopedic devices. When the first rocket ship touches the moon it will probably be made largely of titanium.

Basic types of melting furnaces are discussed in the form of a reference chart as an aid to visualizing both the progress and some of the problems in this still highly specialized phase of the industry.

"COLD ROLL FORMING"

by ELMER J. VANDERPLOEG, Chief Engineer, The Yoder Co., Cleveland, Ohio.

ELMER J. VANDERPLOEG

▲COLD roll forming is a process of forming metal from cut-to-length strips, coiled strips, or sheets, into shapes of uniform cross-section, by passing the material longitudinally through a series of driven roll passes.

Starting with the automotive industry when the demand for mass production and interchangeability of parts created a demand for this type of equipment, its use has now spread to all types of modern transportation equipment, the home appliance industry, building construction both commercial and residential, furniture, and in any field requiring the forming of uniformly accurate metal parts at a high production rate.

Cold roll forming machinery is built in a range of sizes to form material from several thousandths of an inch in thickness up to one-half inch thick, varying in hardness up to the high strength steels used for structural purposes. Spindle diameters on these machines range from one up to fifteen in., and number of roll passes from two to thirty or more. Products range in size from the small toy railroad track, made from five to ten thousandths thick tin plate, up to twenty-six in. diameter one-half inch wall pipe.

Combined with other types of equipment such as flying and shear cutoff presses, welders, polishing heads, painting equipment and others, cold roll forming machines are being used where automation is necessary to produce parts economically and accurately. The efficiency of these machines is further enhanced by the use of supplementary equipment for preparing and handling the material before it is processed in the roll forming machine. Slitting equipment, butt welders combined with looping lines, and conveyors and handling equipment are often used to augment roll forming equipment in plants where their cost can be justified by production requirements.

Modern roll forming machines, designed for quick changeover of rolls, are often supplied with rolls and tooling for a number of different shapes. The cost of this tooling depends somewhat on the needs or use to which they are put. The material from which the rolls are made ranges from hardwood for short production runs of very light gage material to the highest grade of abrasion resistant steel for long production runs of hot rolled unpickled heavy gage steel.

The life of the tooling depends on the gage and surface of the material being formed, the design of the rolls, the material from which the rolls are made, and the lubrication and care which is given to the rolls.

Although practically any formable material can be processed in cold roll forming equipment, this paper is concerned only with the various types of steel, which today is the most common of all material being roll formed. All types of steel suitable for forming by any method are readily formed by this process. Many different types of coated steels are successfully roll formed, including highly finished stainless and the comparatively new prepainted steels now being placed on the market. Both slit material and mill edge material are used today. Because a certain amount of coining and embossing can be done in the process, the sharp edge of slit stock can be generally rounded off in the roll forming where necessary, avoiding the need for mill edge or pre-conditioned edges on the material being formed.

The future expansion of the cold roll forming industry depends to a large degree on the product engineer, who looking for a better and more economical method of making his product, designs into it parts readily

made by this process. In some fields the process is known well and used to its fullest advantage, while in other fields, especially where heavier gage, high strength steels are used, cold roll forming has not been used to its fullest advantage.

"A-2 11-IN. ROD MILL, JONES AND LAUGHLIN STEEL CORP."

by N. A. HANSEN, Superintendent, Rod and Wire Dept., Jones and Laughlin Steel Corp., Aliquippa, Pa.

N. A. HANSEN

▲THE mill starts with a 2½ x 2½-in. x 30-ft billet weighing approximately 600 pounds. In charging these billets they are placed on skids, mechanically separated, and placed on roller table, and then charged, generally three at a time by rack and pinion-type pushers.

Heating is accomplished in an end-charge, two-zone suspended, roof-type furnace with an effective heating length of 60 ft. Fuel is natural and/or by-product coke oven gas. Furnace hearth temperature is approximately 2150 to 2300 F.

The roughing train consists of eight stands (two 16-in. and six 15-in.), in line, driven in pairs by four 500-hp motors. The 16-in. stand rolls are 28-in. face x 17-in. diam. The 15-in. stand rolls are 28-in. face x 16-in. diam. Stands are mounted on a sliding base to permit shifting to maintain constant pass line. Passes used are alternately diamond and square.

An electrically operated flying crop shear is located at end of roughing train to crop front ends of stock prior to entering first intermediate stand. Positioning and operation of shear is automatic, this being accomplished through the use of photo-electric cells.

The intermediate train consists of eight 12-in. stands driven in pairs by four 800-hp motors. Rolls are 26-in. face x 13-in. diameter. Stands are mounted on sliding bases to permit shifting to maintain constant pass line. Passes are alternately oval and square. There are two 180 degree repeaters in the intermediate train, namely, between No. 12 and 13 stands and between No. 14 and 15 stands. There is also a 180 degree repeater between No. 16 and 17 stands.

The finishing train consists of six 10-in. stands driven by one 2000-hp motor. Rolls are 20-in. face x 11½-in. diam. Passes are alternately oval and square to finishing stand which is round.

There are six individually driven laying reels for sizes $^{7}/_{32}$ to $^{11}/_{32}$ in. inclusive. There are also six individually driven pouring reels $^{23}/_{64}$ to $^{21}/_{32}$ in. inclusive.

Mill accessories include:

1. Pinch rolls, selector switch and safety shear located between furnace and first roughing stand.
2. Top and bottom roll adjustment and hydraulic roll separation on all stands.
3. Anti-friction radial and thrust bearings with automatic grease lubrication on all roll necks.
4. Gear type spindles and couplings on all stands.
5. Snip shears located ahead of stand No. 13, 15 and 17.
6. Solenoid-actuated, air-operated switches together with cooling troughs ahead of both type reels.
7. Drag and hook conveyors with total length of approximately 2700 ft.
8. Mechanically operated unloaders to remove coils from hook conveyor.

Mill auxiliaries include:

1. Two cobble ballers.
2. Thirty set-up stands to expedite changes.
3. Oil cellars for mill lubricating and hydraulic systems.
4. Motor room.
5. Operating pulpits—mill and reel.
6. Guide shop.
7. Bearing shop.
8. Roll shop.

"CAUSES OF ROLL BREAKAGE"

by CHARLES F. PECK, JR., Assistant Professor, and F. T. MAVIS, Professor and Head, Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

C. F. PECK, JR.

▲THIS paper presents the second phase of the study of fractured iron work rolls being carried out at Carnegie Institute of Technology under the joint sponsorship of AISE and RMI. In the first paper, a method of analysis was presented which gave the temperature stresses in a hypothetical roll. This work, which was reported at the 1953 Fall meeting of AISE and appears in the June 1954 "Iron and Steel Engineer," is extended to find the temperature stresses in a real roll at any time after start of rolling. The solution is based on roll temperatures measured at Bethlehem Steel Corp., Sparrows Point, Md.

F. T. MAVIS

Stresses in the same roll which are set up by the mechanical work of rolling are also given. The pressure stresses at the point of contact between strip and roll and between back-up roll and work roll are determined analytically as are the bending stresses. Stresses within the work roll have been analyzed photo-elastically.

These analyses and practical data obtained from the sponsoring committee and mill operators form the background for recommendations on how much to crown rolls and how to control temperature stresses during rolling.

"NEW POWER, STEAM AND BLOWING INSTALLATIONS AT OHIO STEEL WORKS"

by J. P. KATZENMEYER, Project Engineer, United States Steel Corp., Youngstown, Ohio.

J. P. KATZENMEYER

▲AT the close of World War II, Ohio Steel Works found itself with power, steam, and blowing facilities of antiquated vintage that, through continued use at peak capacities, had deteriorated to the extent that immediate replacement was necessary in order to avoid curtailment of production. The actual rate of deterioration was so rapid during the construction period, that it was often questionable whether the new facilities would be in operation before the old facilities became inoperative.

Several temporary measures were utilized in an attempt to alleviate loss of production, while a plan for replacement in function of the worn out equipment could be worked out and executed. These temporary measures included the transfer of a turbo-blower from Edgar Thomson Works to permit a reduced rate of operations on old gas and steam blowing engines; the transfer of two frequency changers from South Works to relieve a power shortage by purchasing power; and the installation of a 14-in. steam line, parallel to an existing 20-in. line, to reduce pressure loss and permit a higher throttle pressure on the existing turbo-generators, thus increasing their kw output and permitting decreased loading of the deteriorated gas power engines.

Final replacement of the worn out facilities included three turbo-blowers, cooling towers, complete switchgear for all generators and distribution circuits, two high pressure blast furnace gas fired boilers with blast furnace gas precipitators, and a topping turbo-generator that exhausts into the existing plant steam system, thus relieving a steam shortage.

This paper covers a complete description of the problem, the temporary solutions, the final solution, the new equipment installed, and the interesting sidelights in connection with the many problems involved when new equipment is installed in an existing plant without loss of production.

"A POWER PLANT REPORT TO MANAGEMENT"

by STANLEY A. NELSON, Supervisor of Plant Engineering, Deere and Co., Moline, Ill.

▲ HOW many engineers prepare an annual report to their company's management on the operation of their power plants and consumption and cost of utilities? Those who do not probably wonder why they should since their plant produces all the steam, electricity, compressed air, refrigeration, or other services needed.

STANLEY A. NELSON

Perhaps this question can best be answered by asking four other questions and replying to them.

1. *Why keep records and make reports?* — Records and reports are a means of knowing how well operations are being carried on and what the costs of the various services and utilities are. They are a means of transmitting information from one person to another and serve as a proof to the person and his employer that he is doing a good job.

2. *What should go into reports?*—Only the minimum information that is necessary for guiding the operation and maintenance of a power plant or using the utilities to best advantage should be included. Records and reports should be concise and useful. Remember an executive's time is valuable.

3. *When should records and reports be available?*—In order to be of most value in guiding operations, records and reports should be available as soon as possible after the data is taken. Otherwise, the reports will only serve as historical data.

4. *What should be done with them?*—Train people to know what the recorded data means and what they can do to correct poor operating conditions noted thereon. The engineers should study the results to determine what economies can be effected by careful operation of equipment or by the installation of new or modernized equipment. Remember that management is primarily interested in getting the most for every dollar spent.

One must not lose sight of the fact that even though records and measurements are seldom 100 per cent correct at all times; it is far better to have a 90 per cent correct record to work from than none at all.

"THE EFFECT OF CHANGES IN GAS COMPOSITION ON THE UTILIZATION OF FUEL GASES"

by EDWIN X. SCHMIDT, Development Supervisor, Cutler-Hammer, Inc., Milwaukee, Wisc.

EDWIN X. SCHMIDT

▲CHANGES in gas composition frequently interfere with the satisfactory utilization of fuel gases. The undesirable effects on combustion behavior of changes in gas composition can frequently be reduced or eliminated by the selection of favorable adjustments of gas burning equipment. It is also possible to control

changes in fuel gas composition to reduce objectionable combustion behavior.

Considerable information on combustion behavior is available under the classification of gas interchangeability in connection with domestic appliance behavior. Much of this information is useful in connection with any combustion problem. In the writer's opinion, the forms in which this information is presented makes it difficult to apply the information to the solution of practical combustion problems.

A procedure is offered which should be of value in a better understanding of the subject. In this procedure, those properties of gas which affect combustion behavior are ascribed to each gas independent of the corresponding characteristics of another gas which might be substituted. In some instances these properties of the gas are related only to the type of gas; in others, burner adjustments are also involved. Specific data in graphic form is presented for a number of commercial gases.

In determining the effect of substituting one gas for base gas, data for the two gases are combined in a composite interchange graph. The procedure involved in the preparation of the interchange charts is simple and involves merely copying the combustion data charts with a suitable shift in relative position based on relative values of two properties of the gases.

The composite interchange graph offers a great deal of information on combustion behavior. It directly shows the effects of burner adjustment on relative combustion behavior, and the quantitive changes in burner adjustment, which will help in producing satisfactory operation on both gases.

Samples of interchange charts involving propane-air mixtures as a substitute for natural gas and for coke oven gas are presented which illustrate some of the interesting and in some instances apparently bizarre effects of substituting one gas for another, and the effect of initial burner adjustment on such effects.

Although the information presented is based primarily on interchangeability information based on experience with domestic appliances, much of the information is applicable to any combustion problem, and should be of value in the solution of such problems.

"OPERATION OF MAGNETIC AMPLIFIER CONTROLLED TANDEM MILLS"

by J. W. BRINKS, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., and J. C. PETH, Chief Electrical Engineer, Pittsburgh Steel Co., Monessen, Pa.

J. W. BRINKS

▲ANYONE associated with the iron and steel industry knows that when steel mill equipment is purchased it almost invariably represents the most modern equipment available to perform the function for which it has been purchased. Emphasizing this is the increased use of magnetic amplifiers on suitable regulating system applications. Perhaps the most notable of the new applications of magnetic amplifiers is their use as the complete generator regulation and excitation components of tandem cold strip mill control.

Early this year, a 66-in. wide four-stand tandem mill was put into service at the Allenport plant of Pittsburgh Steel Co. The mill, having a nominal delivery speed of 3190 fpm, has a total stand and reel connected horsepower of 17,700. Individual generators supply power to each stand and reel.

J. C. PETH

The voltage of each stand generator is matched to a common reference bus through a 400-cycle magnetic amplifier voltage regulating system. Any difference between generator and reference voltages will cause a corrective signal in the control winding of the regulator. An IR drop magnetic amplifier introduces a compensating signal into the control circuit to compensate for stand motor IR drop.

The general scheme of reel control is similar to that using rotating regulators except magnetic amplifier components are used.

The ordinary run of magnetic amplifier applications utilizes a 60-cycle, a-c supply system. But the fast response and high accuracy requirements of the tandem mill regulating system led to the development of a 400-cycle magnetic amplifier tandem mill control. Since the response time of the magnetic amplifier is inversely proportional to the supply frequency, the advantage of the 400-cycle system can be readily appreciated.

A second four-stand tandem mill with complete magnetic amplifier control is expected to begin operation late this year in eastern Pennsylvania, and a third in Ohio sometime in 1955.

The performance of the Pittsburgh Steel tandem mill and the results of extensive computer studies and factory tests have served to point out the improvements resulting from the complete use of magnetic amplifier regulating systems on tandem cold strip control.

"MAINTENANCE AND REPAIR EXPERIENCE WITH VARIOUS HYDRAULIC SYSTEMS ON CHARGING MACHINES AND MANIPULATORS"

by ROBERT S. BOGAR, Assistant Chief Engineer, Bethlehem Steel Co., Johnstown, Pa.

ROBERT S. BOGAR

▲IN recent years, and especially since the close of World War II, the use of hydraulic drive systems for the hoist and grip motions of charging machines, manipulators, and the like, has become increasingly popular.

The application of nominally standard hydraulic components to many of these machines by

the original designers proved in some cases to be a serious mistake.

Most such applications for steel plants come under the heading of special, heavy-duty equipment and must be designed accordingly.

The paper describes in some detail a total of ten different hydraulic systems as applied to sixteen machines in four different steel plants. All of these systems required a certain amount of correction. Most of the corrective measures applied to these various systems also applied specifically to one particular group of six charging machines.

Over a period of several years, numerous corrections were made to the systems on these six machines. The troubles, corrections and improvements are described in rather complete detail. These measures proved to be very beneficial, but experience gained through this experience pointed the way to further gains in the development of newer, more simple, and more rugged hydraulic systems.

Initial success of the first simple improved experimental system expedited the design and installation of several improved experimental systems which have to a very great degree eliminated the difficulties associated with this group of machines. The successive steps in the improvement and simplification of the experimental systems are completely described.

The present systems embody all of the improvements as developed through the experimental program. With proper preventive maintenance, these systems are highly satisfactory both from the operating and maintenance standpoints, and the inherent advantages of hydraulic operation recommend them for many steel plant applications.

"A NEW DESIGN CONCEPT FOR D-C MOTORS"

by WILLIAM R. HOUGH, Engineering Vice President, and R. A. GEUDER, Manager, Industry Sales, Reliance Electric and Engineering Co., Cleveland, Ohio.

WILLIAM R. HOUGH

▲THE need for more useful power in all industry has grown year by year. Synchronized drive systems have long been common in the metal working industries. With the advance in the art, the useful power—the synchronized drive — has been asked to do more and more to help produce the almost fantastic speeds, accuracy and precision necessary to satisfy the many other complex requirements which yesterday were obtainable only in the laboratory and today are regarded as commonplace in the plant.

Motors that power metal forming and processing machinery, machine tools, presses, conveyors, shears, and an endless variety of production tools must meet demands for fast acceleration and deceleration, smooth, shockless starting, stopping, and reversals, and split-second timing, with hairline accuracy and unfailing dependability. In addition, modern machinery is being influenced more and more by the needs of automation, which means that production is directly influenced by the *rate* of speed change — "dynamic response" — rather than by the mere responses themselves. With needs growing constantly, yesterday's design luxury becomes today's necessity.

R. A. GEUDER

A new concept has grown to meet these needs—new direct-current motors—that with their control can and will produce the required "dynamic response." This new concept, like all new things, has grown from experience influenced by needs of industry.

"PINHOLES IN THIN STEEL AND PINHOLE DETECTING APPARATUS"

by GEORGE H. RENDEL, Research Associate, Research and Development Laboratory, United States Steel Corp., Pittsburgh, Pa.

GEORGE H. RENDEL

▲THE development of hot and cold strip mills, which was introduced in the 1920's and became widely used in the 1930's, greatly improved the production of steel sheet. But like other developments, strip mills introduced many new operating problems. One of these relates to the detection of pinholes, or perforations, in thin-gage cold-reduced strip.

The introduction of pinhole detectors in the 1930's was a major pioneering adventure. Probably the operating experience gained in using pinhole detectors and the necessity of training electronic technicians to service them was the largest factor contributing to the development and extensive use of electronic apparatus in the steel industry.

Early pinhole detectors were capable of detecting holes about 0.031 in. in diameter at strip speeds up to 100 fpm. With the improvements in optics and electronics, the latest pinhole detector will detect holes 0.001 in. or less in diameter at strip speeds up to about 2000 fpm.

The following are some of the most important developments associated with pinhole detectors:

1. A portable plug-in-type analyzer designed to check performance of detector circuits and electronic components.
2. High-speed control circuits that permit diverting product containing closely spaced pinholes.
3. A sheet pinhole detector designed to inspect and classify perforated sheets as they pass along a conveyor belt.
4. Special controls designed to divert a single sheet on a high-speed processing line. This control permits the diversion of a perforated sheet without the necessity of diverting at least one sheet before and one or more sheets after the perforated sheet to insure diverting the perforated sheet.

Without proper maintenance, the modern pinhole detector rated to detect 0.001-in. diameter holes will be no better than the earlier, less sensitive detector. The most common causes of poor performance are vibration, dirt, and faulty shielding from other electrical apparatus or extraneous light.

"CONTINUOUS DRAWING OF COLD FINISHED BARS"

by WALTER J. PROCHAK, Assistant Superintendent, Cold Drawn Bar Dept., Youngstown Sheet and Tube Co., Youngstown, Ohio.

WALTER J. PROCHAK

▲STREAMLINING of manufacturing processes through the modification of production equipment is the aim of all producers to meet the demands of our times. Old production methods in many cases are cumbersome and inefficient, and in order to meet the present day consumer demands, emphasis is placed on quality, speed of production and efficiency of production.

It is the intention of this paper to describe the design of a production line with maximum speed and economy for the output of ¼ to ⅝-in. cold finished bars. These bars involve a number of shapes including rounds, hexagons, flats and squares. Bessemer grades in rounds and hexagons; and low to medium carbon and alloy grades in rounds, hexagons, squares and flats are all processed by this method. The development of this production line modernized an operation which in its origin consisted of pointing, drawing, straightening and cutting to length of individual hot rolled coils.

After considerable study of various layouts of the operation, a plan for a completely streamlined continuous processing operation was developed. This study led to the present layout of four separate and individual processing lines consisting of a pointing machine, welding rack, welding unit, feed reels and a straighten and cut unit.

The benefits derived from the new lines are reduced handling, increased yield, reduced maintenance and a much safer operation.

"TEN YEARS OF MECHANICAL DESCALING OF HOT ROLLED STEEL PRODUCTS"

by GILBERT D. DILL, Engineer in Charge of Steel Div., American Wheelabrator and Equipment Corp., Mishawaka, Ind.

GILBERT D. DILL

▲ THIS paper gives a brief history of the mechanical scaling process in the past and its development over the past ten years. The paper covers applications and benefits in the following fields.

1. Ingot mold conditioning.
2. Slab and billet conditioning.
3. Continuous strip descaling.
4. Sheet descaling.
5. Bar descaling for cold drawing.
6. Wire rod descaling for cold drawing and heading.
7. Descaling of structural shapes.
8. Mill roll etching.
9. Miscellaneous:
   a. Preparing surface for coating and/or cladding.
   b. Special finishes.
   c. Pipe skelp for electric welding.

The paper ends with a general summation of the mechanical cleaning process and its future in the steel industry. A large number of operating units have been installed because the process helps eliminate the problem of acid disposition which becomes difficult in many locations because of stream pollution laws.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill," published by the Association of Iron and Steel Engineers. If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Use of Models for Layout and Planning

By J. C. MONTORO
Supervisor of Maintenance Cost Control
Lukens Steel Co.
Coatesville, Pa.

. . . . study of models was of great benefit in planning this steel plant centralized maintenance shop . . . .

▲ THIS paper presents a basic general analysis of some of the many influencing factors involved in models for plant layout. No attempt is made to provide a cure-all in analyzing or weighing individual problems and varying conditions, both economic and productive, prevailing in individual companies.

There is a natural human resistance to change in any form. However, when economic necessity demands that the obsolete, ineffective methods responsible for excessive costs be replaced by standardization and improved methods so vital to the controls and reduction of operating costs, any company in a precarious financial position must change or be faced with dissolution.

"No war, no strike, no depression can so completely destroy an established business or its profits as new and better methods, equipment and materials in the hands of an enlightened competitor."

The model as an engineering, planning and management tool, although poorly understood by industry, has been widely developed in recent years. While many ship builders, aircraft plants and chemical industries have used models as an aid to design, layout planning, production control and instructional devices for quite a few years, industry as a whole has considered the model a luxury of dubious value.

Influencing factors in the use of models for plant layout may be analyzed as follows in seven major steps:

1. Economic analysis and "salability".
2. Scope of problem.
3. Pre-planning.
4. Why use a model?
5. Type model to use.
6. Cost of models and layout.
7. Chief advantages.

ECONOMIC ANALYSIS AND SALABILITY

The relative high initial cost of scale models, despite their many advantages, generally places a "wet blanket" limitation by many managements in their ultimate use. However, despite many objections the economic justi-

Figure 1 — View shows model which was prepared prior to construction of new centralized maintenance building.

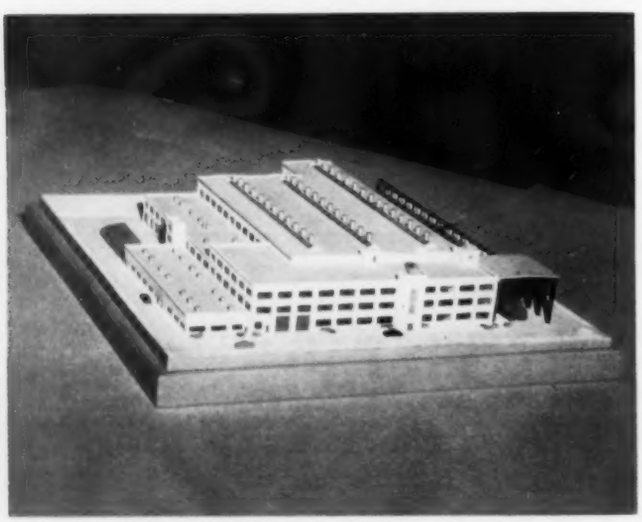

Figure 2 — Actual view of building looking north shows similarity to model in Figure 1.

fication of the use of three-dimensional scale models can invariably always be justified in the planning of a new plant, new building, process or product in any but the smallest plant.

Industrial plant planning and layout is, in essence, a coordinating activity rather than a fundamental science and therefore involves practically every function and activity of the plant. Everything that is done in planning the layout affects some person or activity in the organization so that the success of the plan depends largely on its "salability" before it is made a reality.

Without question, the objective of every plant today is that the required product be produced in the best and cheapest method, be of the required quality and be produced at the required time.

Efficient production requires accurate knowledge of all essential facts relating to the utilization of personnel, materials and equipment. Many companies lack adequate information, and management's failure to attain and properly analyze this information is often the reason for results far below what should be expected from the available facilities.

By actual measurement, waste in industry — that is, the difference between actual and standard costs — averages more than 35 per cent. The waste may be in such obvious forms as "waiting around" or excessive scrap or idle equipment. But more often it comes from causes not so readily observed. In this category are the innumerable items of lost time and effort due to faulty tools and equipment, unbalanced operations and manpower, poor planning and scheduling, improper working conditions and assignments, inadequate supervision and process and equipment limitations.

Mr. C. F. Kettering, the brilliant engineer, has a game which he calls "going into mental competition with ourselves." It is played after this fashion: You say: "Suppose I were to lose my job today and take another job with our competitor who is across the street. I should look back at this company then and say, there are certain weaknesses in it; certain things ought to be changed" Says, Kettering: "Why wait to lose your job? Why not strengthen the weaknesses right now? Why not make the changes at once?"

If we do not make the changes for ourselves, time and circumstances will make them for us.

Today's profits will not come from lower material costs. They will not come from lower labor costs. They will, however, come from increased operating efficiency of present and proposed facilities which in turn will lower unit costs.

SCOPE OF THE PROBLEM

Boiled down to its simplest elements, the problem of plant layout with the utilization of models consists mainly of a given number of machines and men which must fit into a given area. Provision of ample space must be allowed for materials, equipment, material handling facilities, inspection departments, store rooms, offices, washrooms and all other necessities of modern manufacture.

In planning the arrangement of equipment in a new plant or an existing plant, some method of visualization is of great value. No amount of calculation will serve so well as a scale layout that will indicate equipment location, aisle space, storage areas and working areas.

Reading a drawing and thoroughly visualizing a piece of complicated apparatus or facility layout in completed form is sometimes difficult even for the technically trained man, and for this reason, the model can and does play an important part in speeding up production. As a result, they are being used not only to facilitate an understanding of apparatus to be built, but to work out problems in design as well.

Models of interiors are the most widely used type. They may range from the simplest block forms to elaborate projects in wood, metal and plastic. The components may be static, movable or mechanized. Whatever their construction, all of these models are used for one common purpose — to save time and money. Scale models serve to demonstrate the layout problems of an office or factory. The miniature forms point the way to better space utilization, manpower distribution, safe operation, effective lighting, location of utilities, and storage. Space and operation analysis with scale models is an accurate means of pretesting layouts for possible bottlenecks, ease of operation, and general efficiency. This is

Figure 3 — Die department of centralized maintenance building is shown looking north.

Figure 4 — Light machine shop is shown here.

Figure 5 — Carpenter and pattern shop is very well lighted.

Figure 6 — Adequate storage is provided on the second floor.

also the most effective way for departmental heads to work out related problems of production.

Plant and office layout models are used not only in the initial stages of planning, but as a continuous check. For this reason they are considered sound business investments by engineers, purchasing men and management consultants. Sharp improvements in methods and products become visible because the model eliminates extraneous details and gives you a chance to see operations as a whole. Changes in production or expansion of facilities can have their dress rehearsal in miniature, saving costly delays and expensive changes in plan.

PRE-PLANNING

The first step is to gather basic information on the product to be manufactured. Operation procedure sheets breaking down individual operations in elemental time sequence and production intervals should be made, if possible, in order to obtain a proper balance of continuous work flow and a minimum of waste effort and space.

The value of a well organized and planned program of plant layout is contingent upon and in proportion to the accuracy and dependability of the basic information upon which such a program is built. What is good practice for one plant is not always the answer to another, although like programs with adaptions to suit individual requirements may be used in different plants.

Low cost production, which is generally the ultimate objective, demands *minimum movement of men* as well as *materials*. The men who successfully operate plants approach this minimum through best possible arrangement of machinery and equipment and through saving direct and indirect labor. Best model arrangement calls for *flexibility, coordinated straight-line flow, no backtracking.*

SUGGESTIONS ON WHAT TO DO

1. Question every manual handling job in the plant. Consider the possibility of doing it mechanically or eliminating it entirely.

2. Make sure the right equipment is selected for the job — investigate fully the advantages of conveyors, power trucks and tractors, cranes and hoists, and other types of handling equipment available.

3. Consider the use of flow diagrams to show excess travel of parts and products through the plant.

4. Investigate the possibility of using straight-line production methods; weigh the advantages of product over process control.

5. Starting with the premise that about 30 per cent of the operator's motions are waste motions, ask these six questions.

   a. Why should the work be done?
   b. What is to be done?
   c. How is the work to be done?
   1. How much is to be done?
   d. Who is to do the work?
   e. Where is it to be done?
   f. When is it to be done?

6. Can we simplify procedures and methods?

   a. Can the operation be eliminated? If not,
   b. Can it be combined with another? If not,
   c. Can the sequence of the operation be changed? If not,
   d. Can the operation be simplified?

7. Consider the use of idle-time records, process charts, motions and methods analyses and time study.

8. Are material deliveries scheduled and coordinated with their use?

9. Is the plant laid out for straight-line sequence or for process efficiency?

10. Is scrap disposed of without manual handling?

11. Survey to disclose excess inventories of productive and non-productive materials.

12. Analyze receiving, storing, packing and shipping operations for most effective control.

13. Analyze costs of material spoilage due to ineffective layout and coordination, plus excessive costs for rehandling, distance traveled and lost time and delays.

14. Consider the advisability of changing to other forms or sources of heat, in all manufacturing operations that involve its use.

15. Leave no stone unturned in your planned layout that can be justified with an ultimate reduction in cost which will outweigh the initial expense of determining same.

WHY USE A MODEL?

In order that nothing be overlooked, todays industrial complexities require continued explanations and translations of effort among management, personnel, maintenance, production, safety, industrial engineering and other groups. Using a scale model with specific objectives in mind: for example, to train labor, plan repairs or visualize expansions, each person can actively participate in physical demonstrations of ideas through group experiments on the layout.

Many hundreds of hours can be spent by planning engineers in devising a layout and every feature may be mentally visualized by them, but these impressions are often difficult to convey to managers and supervisors by the present practice of template layouts and engineering drawings.

Most executives cannot afford the time to engage in lengthy detail explanations of the layout features which they cannot immediately see when viewing the plan.

Many persons who are required to review and pass judgment on the merits of a layout they may be required to operate do not have a thorough knowledge of engineering drawings and cannot easily visualize the final layout. Others who suggest changes to areas with which they may be familiar often do not comprehend operational structural and mechanical difficulties that may occur as a result of such suggestions.

TYPE MODEL TO USE

As yet, no one has been able to formulate a hard and fast rule by which to determine when three dimensional scale models should be used for layout planning in preference to two dimensional layout plans. However, it is generally accepted practice today that many of the inaccuracies, short-comings and limitations of two dimensional models are eliminated when three dimensional models are employed. The viewers do not have to rely on mental visualization to comprehend the layout. The planners do not have to continually visualize each detail and carry this mental picture throughout the planning. The layout can be prepared, fully utilizing the cubical space rather than the floor areas only as is often done at present. Greater accuracies in work-area layouts result. Finally, and to the surprise of many, the layout can be prepared in much less time and at a much lower cost than by the conventional one-plan method. Some companies have developed rules of thumb for the use of models, but there is as yet little agreement among companies, and even within individual companies, as to their validity. And none of the "rules" gives any consideration to the intangible advantages of the three dimensional scale model — possible greater savings, consultation with non-technical personnel, and "selling" the proposed layout to the men in the shop and to top management.

COST OF MODELS AND LAYOUT

Most persons believe that perspective sketches or three-dimensional models are expensive because they look expensive. However, just the reverse is true.

Cost must be based on at least two factors. First, the initial cost, or the cost to produce the effect desired. Second, the ultimate cost, or the initial cost measured against the results and the intermediate benefits.

In the case of models, it has been found that handmade models, especially prepared for a specific project requiring only a few items, and probably no duplicates, are somewhat costly. However, the results obtained usually justify the cost.

On the other hand, large projects requiring large numbers of models, many of which are duplicates, are cheaper to make than paper templates and drawing layouts.

Models can be used many times whereas paper templates, as a rule, must be made everytime a new layout is planned. In some instances the templates are worn out before the layout is finally completed.

As to results, no one will question the superiority of models over templates. The tremendous benefits gained, in time required to prepare the layouts when working with banks of models, the better arrangements that can be made, and the time saved in conferences and approvals, can hardly be measured in monetary terms.

If a model merely pays for itself, it is a failure. It should do much better than that. Savings credited to a model will usually vary with the number of groups who use it and with the complexity of the object it depicts. Sometimes the cost is shared by two or more groups. It is not possible to predict in advance what total savings can be expected.

Experience indicates that a model of a new and complex process, if fully utilized for design, construction, and plant start-up, will be a very profitable investment. In the case of an average chemical plant or refinery, the model can usually be justified even if used only for the start-up.

There is less need for modeling standard plants because presumably the designers, construction forces and operating men have had experience with the prototype. It may be, however, that a large number of operating and construction men have never seen the prototype, or that design improvements have been made. In this case models may be worthwhile.

Models should not be used where templates or drawings will convey the picture to non-technical personnel. Justification for modeling existing plants should be carefully examined, since it will be submarginal in many cases. The model should have specific objectives: for example, to train labor, plan repairs, or visualize expansions.

CHIEF ADVANTAGES

1. The relationship of various buildings and equipment to each other can be shown in relation to the movement of materials from and to the plant, movement of work in progress, traffic of personnel and security.

2. Economic factors, such as: showing the terrain in miniature, the placing of approach roads and excavations and prevailing winds and solar orientation can be studied and put to use with the aid of scale models; thereby showing a definite effect on construction factors and operating efficiency.

3. On large models, planning factors outside of the site itself such as the effect of highways, water routes, railroad lines and air paths can be shown. The location

of utilities, housing and raw material sources can also be clearly indicated.

4. Scale models have many interesting uses in training employees such as:
   a. The safest routes for the movement of personnel and materials through a plant can be planned and demonstrated with ease. A model showing these routes and indicating potential danger spots for tight clearances, intersections, etc., should not only be used for safety instruction, but should be placed where all employees see it often, so that safety becomes a cooperative day by day affair.
   b. For the prevention and control of fires, the scale model demonstrates the possible trouble spots the locations of control equipment, master switches, fire door and escape routes.
   c. Planning for accident prevention, analyzing accidents and carrying the safety story to employees in a clear, forceful and interesting manner can be done by setting up appropriate scale models.
   d. Demonstrations of maintenance and repair practices are facilitated by the use of models, particularly if some outer parts are made of transparent plastic for easy visibility.

5. Models are built not only to help in speeding up production, but also to facilitate a basic understanding of non-technical personnel in the apparatus to be built and to help technical personnel work out problems in design as well.

6. Models are many times used to prove practicability of ideas and occasionally, models of proposed equipment are made as an aid to artists and draftsmen who must make finished pictures and drawings of the equipment.

7. As a device for communicating ideas and pictures, models have the advantage of an extra dimension over drawings. In attempting to depict three dimensional objects, drawings often sacrifice clarity and fail to convey the complete picture to many people. So many drawings are required for illustration of complex objects that hours of study may be needed before even the experienced draftsman can visualize them. He first translates three dimensional images into two dimensions and then all who use his blueprints must translate them back again. This double translation consumes much time and introduces a double opportunity for error.

Justification for models stems from their ability to make up for these shortcomings in drawings. They are no substitutes for prints, but are a much needed supplement.

SUMMARY

By the use of three-dimensional drawings and models, an exact replica of the plant can be placed before the executives and much guesswork and mental visualization can be eliminated. Many hours of time of valuable men can thus be saved.

It is not likely that anyone will argue against the benefits which arise from the use of visual aids which help bring about sound judgment and result in thorough approval or disapproval of a proposal. It is just putting into reality the literal expression we have often heard, "I can see clearly that this thing should or should not be done."

How often do we have the experience of someone in authority saying, "I am not sold on the scheme," or, "I do not like this arrangement," when we believe he is speaking from a subconscious feeling rather than a real understanding of why he does not like it. When a group of men sitting around a conference table all view the same problem in the same light, then, we shall certainly get better decisions more promptly. Worthwhile projects will have a much better chance of survival with much less likelihood of being the victims of the likes, dislikes, or intuitions of people who may not understand clearly the principles or the objectives. We sincerely believe that the next decade will see the universal use of three-dimensional planning in the science of industrial plant layout.

In layout planning, production control and training, the scale model, imaginatively conceived and intelligently used, is a reliable precision instrument and accurate preview of the shape of things to come.

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DISCUSSION

PRESENTED BY

C. W. DUNN, Technical Coordinator, United States Steel Corp., Fairless Hills, Pa.

WILLIAM KOWALSKY, Chief Mechanical Engineer, Ramseyer and Miller, Inc., New York, N. Y.

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

JOHN S. MORRIS, Supervisor Construction Central Maintenance, Lukens Steel Co., Coatesville, Pa.

M. B. ANTRIM, Assistant Manager, Maintenance and Construction Div., Lukens Steel Co., Coatesville, Pa.

C. W. Dunn: Are there any actual savings directly attributed to the use of models or are they basically intangible as pointed out by the speaker, for executive use?

Does the financial limit within which models are used enter into consideration?

Do you use models simply to eliminate production and maintenance bottlenecks, or are they primarily used on new construction items? If used on maintenance projects, can you give an example of the type of one

which you could use? I think looking at the model will answer my last question concerning the extent to which you use interior modeling rather than the exterior? In other words, how completely did you lay out the interior with actual models rather than with two-dimensional cuts and flow diagrams?

William Kowalsky: While listening to Mr. Montoro, I was reminded of my first experience with a scale model. The model in this case was not as elaborate as the one on display on the table. It was not a scale model of a whole plant but only of a boiler unit. Because I consider it a very interesting application of a scale model, I will tell about it.

Back in 1938, while working for Babcock and Wilcox Co., we had a contract with Public Service Co. of New Jersey, for rebuilding one of the first mercury boilers ever installed in a utility. This boiler is now, with some changes, still operating at their Kearny Station, at Kearny, N. J.

The design of this mercury boiler was unique and differed entirely from all previous boiler installations. The cross-section of the furnace was octagonal, and across the flats of the octagon there was a distance of about 30 feet. The furnace was about 50 feet high and the overall boiler about 100 feet high. The furnace surfaces were completely covered with mercury tubes which, when hot, expanded downward about 3½ inches. As I recall, the tubing was 1 7/16 in. outside diameter with 1/16 in. clearance between tubes, so that the inside walls were covered with contiguous tubes — all alloy and completely welded. One additional detail I recall was that the slag screen ran from the upper mercury drum to the top of the front wall of the boiler in the shape of a catenary, and was about ten rows deep.

After the design was pretty well established on the drawings, someone thought that with the very long lengths of tubing, and with the very complicated expansion system and with a heavily loaded structural system, there may be trouble in the field getting everything installed, and it was decided to build a scale model of the complete boiler. That was done right next to the drafting room and the completed model stood up about 7 or 8 feet high. The complete pressure, piping, and structural systems were laid out to scale and the individual parts could be removed and put back into position. Following completion of the model, it was found that in about, oh, I would say in about fifty cases, it would have been impossible to install quite a few of the boiler components according to the way they showed up on the drawings. Interferences between parts were discovered; the sequence of erection of structural steel was determined by actually going through the steps of putting the model together; platform clearances, location of expansion joints, exterior piping supports — all could be examined in three dimensions.

The model was used in the drafting room and drawings were revised as difficulties were revealed; it was used in the field by the construction department, for determining erection sequence; it was used for training the operators. Now it is the prime exhibit in the plant auditorium and is used for illustrating lectures to apprentices and visitors.

C. E. Pritchard: I am intrigued with this elaborate model on display which depicts the new central maintenance shop. In evaluating the merits of same in conjunction with a central maintenance shop, the question arises as to whether the model is also used with other models to illustrate the movements, on a plant scale basis, of units being transported to the shop for machining, welding, etc. Have studies been made to ascertain what interference problems might be encountered in the movements of parts to and from the shop for any given twenty-four hour period? Does the central maintenance shop reduce the number of departmental shops employed?

John S. Morris: I would like to add to what was said, relative to the usefulness of models in planning new construction work.

In the original planning of the papers committee there were to be several papers on the use of models which would have stressed their use in construction planning. It is hoped that at some future date these papers may be given.

Recently, Bethlehem Steel Co., at Bethlehem, replaced one of their older blast furnaces with a new and larger one. To assure their engineers that there would be sufficient space for construction operations and production operations of other furnaces to function properly, a model of the new furnace with all accessories, and adjacent old furnaces was built. Through the use of this model, they discovered many difficulties which would have been encountered in the construction work, and it enabled them to properly plan and execute the construction.

Models can help you work out construction problems ahead of time — particular where space is limited.

M. B. Antrim: The use of a three dimensional model to lay out the machinery and other facilities in our new maintenance shop has, in our opinion, paid dividends. Admittedly models of this type are not inexpensive, however, we can state with certainty that both our die repair shop and our carpenter and pattern shop at present in operation occupying quarters in this new building have increased their productivity due to the use of such a model.

The effect of careful preplanning concerning machine location, storage areas, office space, etc., in reference to product flow, which preplanning is accomplished with a maximum efficiency when a model is used, does much to eliminate potential managerial headaches.

The effect on employee morale when employees are moved from an overcrowded outmoded shop to one which has been carefully planned to handle the existing work load is also truly amazing.

We believe the paper just presented to be an excellent example in the field of industrial engineering and furthermore, the methods described have resulted in very real benefits to our company.

J. C. Montoro: As to this first question here, "Can you measure actual savings due to the use of models?," from the standpoint of measuring tangible savings, it is not always possible as you would measure a project, for instance, where you can measure reduction from the standpoint of actual labor.

It depends a good bit of course on how you are going to use the model, what you are going to use it for, and the intangible aspects that may result from its use. As already pointed out, you sometimes find out from the use of models, in many, many cases, beforehand, certain troubles that might occur if you had tried to use only

prints or had not visualized them in the three-dimensional aspect. Therefore, to say you have actual savings, you really do not, you have intangible savings by seeing problems previous to actually doing the building or the work.

As to financial advantages, as far as the models are concerned — that is a difficult question to answer. Actually you cannot set a financial limit on it. It depends primarily on the scope of the management, and how far they want to go in the arrangement of the models. In this particular model we were concerned with the project itself which will cost approximately $5,000,000 to construct. Actual cost of the model which was around $4000 reveals that we are dealing with a minute sum in relationship to overall project costs. Furthermore, if you are figuring the scope from the standpoint of a financial limit, you must view it from the standpoint of the model you are going to use. If you are going to set up a permanent model, quite elaborate, of, say, wood, plastic, or other materials that you want to retain for a length of time, certainly it is going to cost more for that type of model than if you set up little block forms that can be used just as nicely. So it depends very much on the extent to which you wish to go.

The second question was "Do you use them to eliminate production problems?" Let me present my experience on it. I know many companies do use models many times to eliminate production problems, where they are realigning present existing departments for better flow or better arrangement. In our particular instance our industrial engineering department, in cooperation with our plant engineering department in most cases does not use the actual model arrangement for the elimination of production problems. We are using templates, with the exception of the By-Products Division rearrangement. In most cases where we have a simple problem we find it expedient to make a small template layout. These are a one shot deal which are cheaply constructed, show us our needs in a quick, simple and concise manner and produces effective results. However, as Mr. Morris pointed out, we again, in the By-Products Division have had constructed a three-dimensional model for planning and rearrangement purposes which is about three times as large.

This model is an actual replica of the three plants, 1, 2 and 3 in the By-Products Division which shows actual columns and building arrangement in detail and at the present time is being used for the rearrangement of all of the machinery in the By-Products Division.

Now, as to what do we do beforehand, insofar as interior modeling is concerned? Mr. Antrim has answered part of that question.

The superintendent of our machine, forge and grind shops, in cooperation with the manager of our maintenance and construction division, and with the other superintendents of the maintenance groups, along with our engineering department and the departmental heads, sat down and planned in infinite detail exactly how these machines will be laid out in the particular model, to see you had no backtracking of material, no interruption of flow in the machine utilization, to see that machine utilization was as effective as you could possibly get it, that you had the least amount of handling, and consumed the least amount of space as far as the installation of the machinery is concerned.

Member: Do you utilize the model on a plant scale, that is, to check the interferences that might occur in moving material to and from a centralized maintenance shop, such as this?

J. C. Montoro: In this particular case I will answer it this way: I will not claim we effectively eliminated all of the handling of our materials in that manner, because this building is not 100 per cent centralized, or is not a completely centralized maintenance program. We have in addition to this building several other sections. Although they do have a centralized maintenance group, there is an arrangement in combination, in the centralized maintenance group, which to us works most effectively. In those particular areas we have considered the movement of our materials, the elimination of excess handling, and so forth, in regard to this particular model. However, we still have many problems to work out on it.

PLAN TO ATTEND

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Spring Conference

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APPLICATIONS FOR LAMINATED FABRIC BEARINGS

By R. L. BERRY

Manager, A-B-K Sales, American Brakeblok Div., American Brake Shoe Co., Detroit, Mich.

. . . . laminated fabrics have many economic applications in rolling mills . . . .

▲ LAMINATED fabric bearings, sometimes referred to as fabrics, plastics, or composition bearings, have a good background of performance and are well received in rolling mills. It might be of interest to outline briefly the inception of this composition bearing and to describe its construction and manufacture.

This bearing originated as a rag bearing developed during an emergency by an operator named Charles J. Brown, at the Donora Works of the American Steel & Wire Division in the late 1920's. Purportedly, Brown, out of brasses and needing bearing replacements in a stand of his mill, placed rags dipped in oil under the roll necks. With this improvised bearing he ran the mill to the end of the turn. Brown perfected this crude application, cutting fabric to size, saturating it with oil, and placing piece upon piece to obtain the proper bearing thickness. The idea was patented as "open faced heavy duty bearings." At a later date, a leading member of the composition bearing industry acquired the Brown patent. Phenolic resins replaced the oil and the carrying medium became various weights of cotton duck and other fabrics.

Today's laminated bearing is manufactured by impregnating with various phenolic type varnishes, different weights of cotton duck and pressing the appropriate layers of treated material in heavy presses. Currently, fabric bearings are pressed under pressures of up to 2000 psi of projected area, cured at temperatures up to 350 F for one hour per inch of thickness, and cooled to workable temperatures while still under pressure. To meet the variety of conditions experienced in the rolling mills, various resins are used in combinations with different weights of fabrics. From these variants come the different composition bearing formulations available in the industry, each having its strong characteristics for various application.

It is the continued effort in the industry to develop a formulation with a high hardness value and also one that maintains a high impact value. In working with these two important factors, we must be sure that the characteristics of compression, tensile and elasticity are maintained to produce a well balanced bearing.

There are essentially two types of applications for the mechanical grades of laminated fabric bearing materials. These are: first, as a bearing for roll necks and thrust applications, where the fabric material has the mating surface moving in relation to it. Here the fabric bearing can be lubricated with water, grease, or oil, or variants of these three. Secondly, as an impact absorbing media in applications such as the universal coupling slipper bearing. With the slipper bearing the use of a tacky adhesive grease is recommended of such specification that it forms and maintains a protective coat between the fabric and mating surface. Lighter lubricant will pean away under impact or be thrown free of the assembly as it rotates.

LAMINATED FABRIC SLIPPER BEARINGS

Typical of an application where laminated plastics serve as an impact absorbing medium is the universal coupling slipper bearing. With the use of laminated fabric slipper bearings, metal-to-metal contact is avoided, spindle slap and noise levels are reduced, and spindle maintenance is minimized. Because of their low hardness value in comparison with the metallics, composition slippers, to operate successfully, should be installed in spindles with close fit and well machined surfaces. Due to their hardness differential, composition slippers should maintain the close fit and machined condition of these spindles. Spindles should Brinell between 290 and 320 for the best performance of fabric slipper bearings. At this suggested hardness, coupling wear is minimized and wear is effected mainly on the replaceable fabric slipper. The use of a high viscosity grease on a composi-

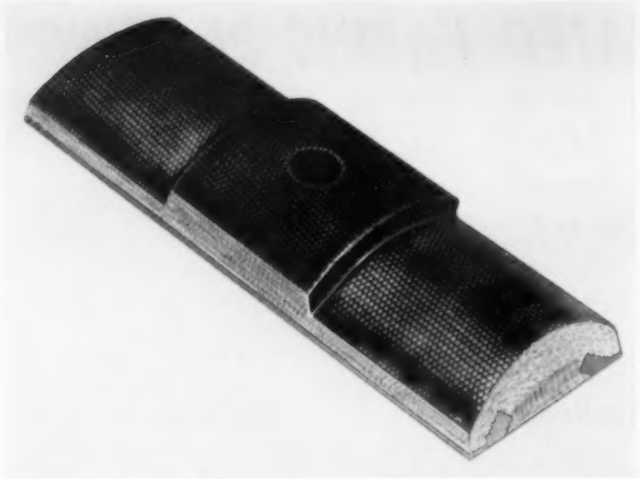


Figure 1 — A ladder of high tensile manganese bronze is embedded in the reinforced slipper.

tion slipper bearing is recommended, applied at installation and periodically during its wear life. For best results, the universal coupling should be protected from scale and other mill abrasives.

Composition slippers give excellent service in applications where there is not excessive heat and, also, where the cant angle of the spindle does not exceed 10 degrees for prolonged periods. Heat of friction or operation can be more rapidly dissipated by playing a lazy spill of water over the coupling. In blooming and heavy duty mills, the best performance is obtained between motor and pinion stand and on the bottom roll spindle at both pinion and mill end.

To better the performance of composition slippers, engineers have incorporated a high tensile manganese bronze casting in their manufacture. This patented ladder is imbedded in the fabric during its manufacture (Figure 1) and serves, among others, two very important functions. Primarily, should a fracture of the slipper occur in its operation, the reinforcing ladder will protect it from complete rupture. Secondly, the ladder protects the laminated plastic slipper when the mill is being reassembled during roll changes and repairs minimizing possible fracture and consequent delamination should the slippers be cocked in the coupling.

LUBRICATION

In all composition bearing applications it is essential to have water inserted into the chucks for lubrication of the composition bearings both for the radial and thrust areas. This is accomplished by insertion of pipes into the chucks. The load zone on composition bearings averages about 130 degrees; the carrier bearing for the top roll is always of shorter arc length. Hence, there is space available between these bearings for insertion of a water pipe. These pipes are drilled with a series of small holes along their length so that water can impinge on the roll neck. Sometimes nozzles are used instead of just small holes to give a fan action, although this may not be essential. The rotation of the necks of the rolls tends to pull the water right into the fabric bearing zone. This radial fabric bearing always is made with a long bevel on the neck side to provide easy access of water into it. Water must also get into the thrust area.

A suggested lubrication practice for thrust collars, especially when the section being run necessitates high lateral pressure — is to make wedge cuts in the face of the collar. The cut to be about $\frac{3}{8}$ in. wide, $\frac{3}{8}$ in. deep at the top tapering and narrowing to nothing at the bottom. The sizes of the cuts and the number used is dependent upon the size of the collar. In an extreme pressure situation, these cuts can be filled with grease. This procedure also reduces initial torque after "down" periods.

As with other types of bearings, proper lubrication of composition materials is of the utmost importance. Many think of fabrics as "water-lubricated," though

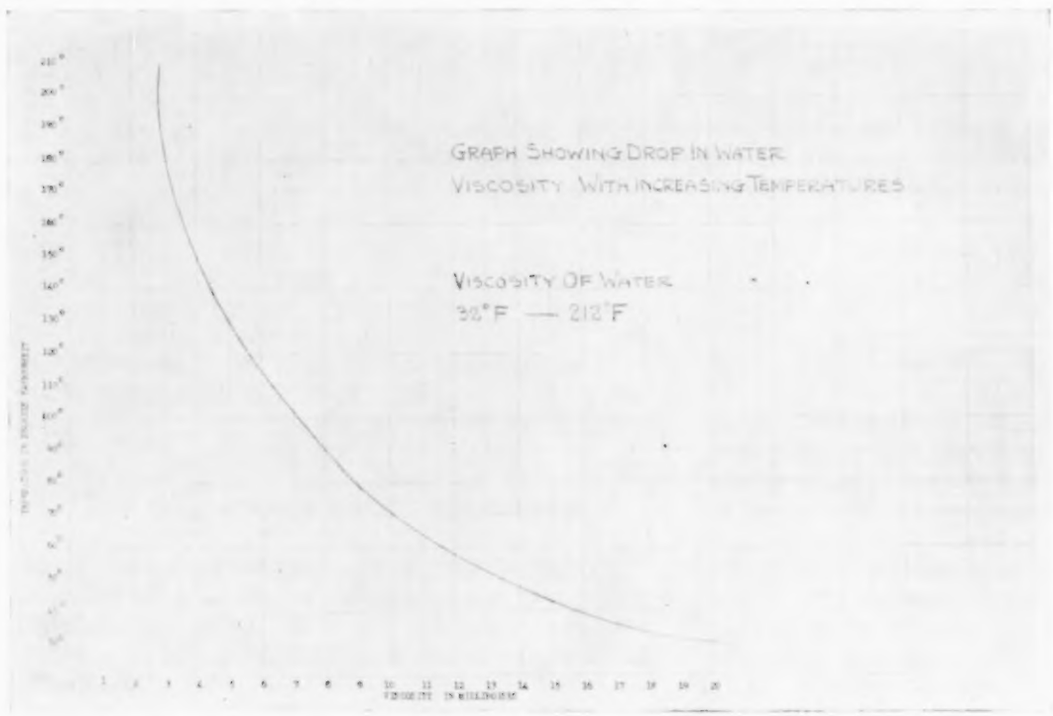


Figure 2 — Viscosity of water decreases markedly with increasing temperatures.

grease, oils and combinations are in constant use. To discuss water lubrication primarily, its function with composition bearings is twofold, both as a lubricant and a coolant. Past experiments have shown quite plainly that merely cooling the bearing surfaces leads to rapid wear. Water in the successful application enters between the bearing and the mating surface forming a separating medium. As the temperature of water increases, its viscosity decreases, and its use above 130 F in the bearing is not recommended. Above 130 F, viscosity is so low (5.0 millipoises) that hot spots can develop and delamination due to localized heating results. See Figure 2.

The use of clear cool water free from abrasives and in sufficient volume to keep the neck assembly cool is the industry's recommendation on composition bearing materials.

With the volume of water necessary for the production of steel, sometimes variants occur in the pH value of the water available. The effect on composition bearings of acid and alkaline water varies according to the bearing formulation involved. Regardless of the ability of fabrics to withstand varying pH in lubricating water, the roll neck can become etched, forming a series of small cutting edges which abrade the material with resulting poor wear. Such effects can be minimized by incorporating in the composition bearing selected fillers of the proper size, shape and hardness so the journal or mating surface is kept polished. This polished roll neck prolongs the life of the bearing. The use of the polishing agent minimizes roll neck wear and reduces the necessity of expensive and time consuming roll neck maintenance. Generally, laminates, properly impregnated and bonded with phenolic resins will very well resist mild acidity or alkalinity without delamination. But because of the variation in degree of acidity or alkalinity in water supplies, ordinarily available to the steel mill industry, it is customary for the bearing engineer to examine the history of the water supply prior to installing the bearing in a new application. Then recommendations can be made, if necessary, to neutralize the water before it enters the mill.

When grease is introduced on a composition bearing, a heavily chamfered hole has proved effective as its method of entry. This forms a lubricant reservoir from which the grease spreads through the bearing area. On reversing mills, two such entry ports are suggested, both located out of the major load area. Either soluble or non-soluble greases are acceptable for these high pressure, slow speed applications of such specification that the film will resist rupture even under maximum loads. Quantities of grease recommended for such applications depend on their specification and the nature of the operation. A good working rule is one-third or less than the quantity necessary for a metallic bearing in the same application.

DEVELOPMENT OF CONTAINED NECK DESIGN

When composition bearing materials were first used in the rolling mill industry it was on the basis of replacing laminated fabric for the bearing material previously used. These substitutions in open chuck design left the fabric material exposed to scale and abrasive conditions. In addition, there was little control of the volume of lubricant needed or provision to lubricate other than manually for shutdown periods. Certain mechanical devices have been added to the "open chuck" design to minimize these disadvantages, and fabric bearings have proved quite successful under such substitute conditions.

Recognizing that laminated fabrics are engineering materials, rather than substitutes for other types of bearings, however, mill builders have developed very sound designs in roll neck assemblies for their operation. These new designs reflect quite positively the economies in initial installation and operation of composition bearing materials. There are, today, many mills which are operating equipment, using the contained neck design with fabric bearings, reporting top bearing performance.

In essence, the enclosed neck design achieves three important advantages over the open chuck design. Primarily, the neck and bearing assembly is fully contained, thereby affording positive lubrication that can be closely controlled both as to volume and pH value of the lubricating water. Secondarily, but equally important, mill scale and abrasives have been eliminated from the bearing areas, thereby greatly diminishing one of the main causes of fabric bearing wear. A third advantage, the enclosed neck design affords a more positive method of introducing supplementary lubrication both for difficult sections and for the "down" periods. A film of petroleum lubricant can be introduced on the bearing and neck areas, thereby minimizing oxidation of the metallic surfaces and reducing starting torque. Such supplementary lubrication can be achieved either by an automatic lubrication system or by a metering device that provides oil periodically during bearing operation.

The major steps in arriving at the contained neck design currently available from the mill builders have

Figure 3 — Thrust segment is a ring instead of the customary collar.

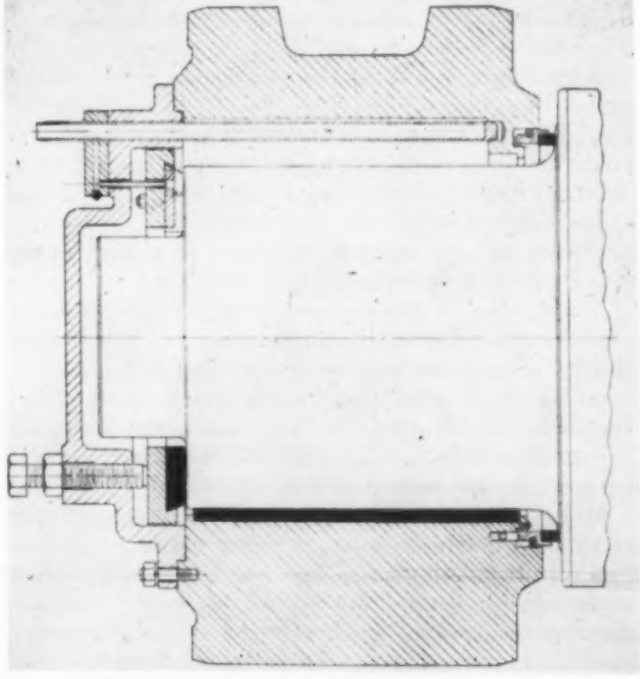


TABLE I

Physical Properties

		Grade 500	Grade 501	Grade 505	Grade 508	Grade 509
Specific gravity, g/cm³		1.34	1.34	1.36	1.41	1.42
Pounds per cu in.		0.048	0.048	0.049	0.051	0.051
Moisture absorption at 25 C, ½ in. thick						
At saturation, per cent		3.0	3.5	.....	.....	3.98
After 2 hr immersion, per cent		0.43	0.31	0.39	0.020	0.17
After 24 hr immersion, per cent		1.20	1.0	0.87	0.55	0.32
Tensile strength, psi	FL* — Flatwise-lengthwise	11,400	9,500	14,200	14,000	13,000
	FC — Flatwise-crosswise	9,700	6,500	7,200	11,400	9,600
Flexural strength, psi	FL	21,300	17,000	22,300	26,000	31,200
(Modulus of rupture)	FC	18,200	11,000	14,600	21,200	27,600
	EL — Edgewise-lengthwise	20,400	16,000	22,300	24,600	33,600
	EC — Edgewise-crosswise	17,100	11,000	14,800	20,100	28,800
Modulus of elasticity in flexure, psi	FL	825,000	750,000	1,045,000	980,000	.....
	FC	750,000	550,000	820,000	1,095,000	.....
	EL	750,000	650,000	1,178,000	1,045,000	.....
	EC	800,000	500,000	833,000	1,099,000	.....
Compressive strength, psi	F	44,700	35,500	40,700	39,000	31,500
	EL	26,000	23,500	22,900	20,500	22,900
	EC	31,000	28,000	24,400	24,900	26,300
Modulus of elasticity in compression, psi	F	.....	.....	454,000	.....	.....
	EL	.....	.....	626,000	.....	.....
	EC	.....	.....	415,500	.....	.....
Impact strength	FL	5.29	7.57	4.60	5.88	9.04
(Izod; ft-lb per in. of notch)	FC	2.54	2.87	2.75	2.75	4.48
	EL	2.86	4.79	2.40	3.27	5.20
	EC	1.66	2.66	1.55	1.86	3.12
Bond strength, lb		3,900	3,100	3,000	2,200	4,000
Shear strength, psi	FL	14,000	12,600	15,400	13,900	.....
	FC	11,200	10,300	12,300	13,600	.....
	EL	12,500	14,500	16,400	.....	.....
	EC	12,400	10,700	13,100	.....	.....
Hardness, Rockwell "M"	F	101	92	105	101	105
	E	95	74	96	95	94

*Letters F = flatwise, L = lengthwise, E = edgewise, C = crosswise, referring to directions of laminated structure.

been roughly as follows: Originally the open chuck design was modified by the addition of seals at the ends of the rolls. This seal kept water from pouring out the ends of the bearing chucks onto the mill floor. Also a spring loaded fabric half ring was used on the bottom roll, rubbing against the roll body, to minimize entrance of scale and mill water into the bottom bearings. See Figure 3.

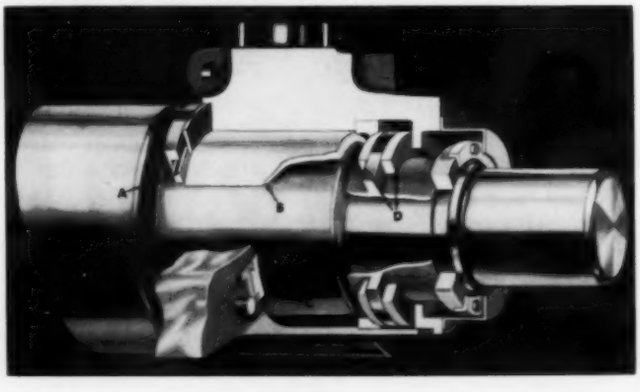
Next step was to take the roll thrust at the roll end, rather than at the fillet. This thrust segment became a ring instead of the conventional collar, so thrust area could be increased by the addition of thrust rings, should the sections for which mills were designed require very close lateral adjustment. Seal rings were provided at both the roll body and end, with appropriate part design for seal wear.

More recent contained neck designs have provided for thrust of the roll in either direction in only one chuck. This is accomplished by various methods of rings and thrust discs on the roll and opposite the drive. By anchoring the thrust in only one chuck, problems that had occurred previously due to roll expansion have been greatly minimized (Figure 4).

Mills so equipped with contained neck designs report many advantages both in operation and maintenance. The resultant compact design has few interdependent parts, can be dis-assembled relatively easily, and only those parts showing greatest wear need be replaced. Spare part inventory can be maintained with a minimum of care and expense. Due to the light weight of laminated fabric part, spares can be handled and installed manually. The resilience of laminated fabric affords protection to the bearing against the heavy impacts experienced in many operations.

In summation, composition bearings afford many additional possibilities for use in bearing applications when properly designed, installed and lubricated. Water should be relatively free from abrasives and foreign substances and available in sufficient volume to keep the journal and assembly cool. Lubricating water between the limits of pH6 and pH8 is preferable for use on laminated composition bearings. If more acidic or

Figure 4 — By taking care of the thrust in only one chuck, many expansion problems are eliminated.



basic, it may be neutralized at the source and a filler bearing considered. Fabrics will not stand up under constant scaling conditions or in the continued presence of foreign substances in the lubricating water. With adequate filtration systems and scale guards, however, these difficulties can be minimized. Roll necks and the mating surfaces should be, wherever possible, smooth or ground. When in such condition, and presupposing acceptable lubrication, they will be so maintained by the composition bearing.

Laminated phenolic bearings can provide power and lubricant savings, will afford uniform wear necessitating few mill adjustments for gage. Their low density and high strength to weight ratio makes their removal or replacement easier and their storage and availability in the mill less of a problem. Laminated bearings will not pean out or take a set, and their ease of replacement in the mill minimizes expensive "down time."

DISCUSSION

PRESENTED BY

R. E. WRABLEY, Master Mechanic, Rolling Mills Maintenance, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

L. W. GILCHRIST, General Foreman, Cold Reduction Maintenance, Irvin Works, United States Steel Corp., Dravosburg, Pa.

R. L. BERRY, Manager, A-B-K Sales, American Brakeblok Div., American Brake Shoe Co., Detroit, Mich.

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

R. E. Wrabley: Recently we put into operation a new 10-in. bar mill, equipped with fabric bearings. Previous to deciding on the open type bearings, the possibility of using the closed type chuck was investigated.

The 22-in. mill of Sharon Steel plant was visited, where closed type bearings are in service. Their set up was very good, but the initial cost of this application resulted in our decision to select the open type bearing with fabric liners. Presently, we are working on a closed type bearing design to apply on our 14-in. bar mill.

I think the closed type bearing is a very good design, that will result in a minimum of bearing cost.

L. W. Gilchrist: The author has covered most of the trials and tribulations we encountered in installing fabric bearings in hot strip mills. I had the opportunity of installing fabric bearings in four roughing stands of a twenty-two-in. strip mill. I believe this to be one of the first installations of fabric bearings in this type of mill.

When we started the mill up, we had many a headache in trying to keep the mill operating and maintenance delays down due to bearing failures. We were using unfiltered water right out of the river which contained quite a bit of dirt and sand.

The sprays in the bearings had a 1/16-in. orifice, and plugged up very easily. Also the thrust ends of the bearings were open and the scale gave us quite a bit of trouble as it would destroy the thrust in a very short time and then enter the bearing. We were thus initiated in fabric bearings on hot strip mills with about the worst conditions that could prevail. We overcame the spray plugging by gradually increasing the size of the orifices in the sprays from 1/16 to 3/16 in. We then developed a seal for the thrust end of the bearing to prevent scale from getting into the bearing. After that we had fairly good success, although at times when the river was high and muddy, we would experience difficulty with our piping.

Later I had the opportunity of installing a 14-in. hot strip mill with six stands of finishing mills using fabric bearings on the finishing train with a delivery speed of 1900-2000 fpm. With our experience on the 22-in. hot strip mill, we immediately began increasing the size of the orifices in the sprays. With the higher speeds, this was not sufficient, so we increased the size of the spray pipes in the bearing from 1/4 to 3/8 in. and increased the supply lines from 3/8 to 3/4 in. This gave us some relief. We then tried pumping grease into the bearings at regular intervals, but this proved of little value as the grease would eventually plug up the sprays and our water outlet lines. We eventually eliminated the periodic greasing and settled for greasing the roll neck when we inserted the bearing. We also increased our water supply lines from 3/4 to 1 in.

With this arrangement it gave the bearing an ample supply of lazy water, and we had fairly good success under the conditions. After this was completed, the mill men complained about the water around the mills when they were setting the mills up. Oftentimes they would shut the water off with the mill turning over and we lost several bearings this way. In order to overcome this, we sloped the floor in front of the mill and designed adequate shields to prevent water from splashing out on the floor.

Then, a little later on I had an opportunity of putting in a 14-in. mill with six stands, and in that case, too, we just had to keep going up on the amount of water until the bearings were completely filled. You must have clean water to operate.

R. L. Berry: I would like to ask those in attendance here who are operating mills, how many of the mills have separate water systems with enclosed neck designs for lubricating the composition bearings?

How many have the same water for cooling the rolls?

R. E. Wrabley: We use spray pipes on all fabric bearings. The main supply for pass and bearing water, passes through 3/8-in. mesh strainers. The bearing water is again passed through 1/8-in. mesh strainers.

Without this finer mesh strainer, considerable plugging of the spray pipes on bearings can be expected, resulting in insufficient water and ruining of the fabric liners and collars.

Member: We installed a 56-in. hot strip mill, and it is very, very important that we have found out how to keep sufficient water on them. As he says, the operators will turn the water down mainly to keep their feet dry. We have found out that insufficient water will crack them and eventually will eat them out and completely destroy them.

We do not have a spray system of water on our mills other than the mill water.

Now, we tried these slippers without too much success, and I would like to hear some other comments on the slippers of someone who has used them and perhaps

use them with some degree of success, and how did they use them?

We found out that on the slippers themselves, we had trouble with impact. We could not keep the lubrication on them, mainly because of what he said a while ago, a heavy enough lubricant with a high enough viscosity will throw itself away from the slipper. Through impact, these just wear out in no time at all.

R. L. Berry: Did you try the fabric slipper with the tacky lubricant?

Member: Yes.

R. L. Berry: Did that improve the performance?

Member: No, we had only one set.

R. L. Berry: Was it reinforced, or was it fabricated?

Member: It was reinforced.

R. L. Berry: Any slipper bearing, without proper lubrication, will not perform especially one of laminated fabric construction. A tacky lubricant is called for and I should imagine might increase the performance of the slippers in your application.

A. E. Cichelli: All of us would be interested in learning on what type mills these slippers have been used?

R. L. Berry: They are on regular finishing mills, which mills are subject to perhaps greater shock loads. They are also on a hot strip mill.

Of course, in rolling carbon, high silicon and, the alloy steels, perhaps they are subject to greater shock loads than the normal mills.

Member: I have somewhat of the same problem in the 10-in. mill. We have two vertical edging passes. The last vertical is set at about 2500 fpm and we use drawn slippers now.

R. L. Berry: With regard to the fabric slippers, we have them, or they are installed in many mills, blooming mills, slab mills and billet mills and again, the bottom roll mill end is not so hot. The further you get away from that, the better the operation of the mill as is true for most wearing parts. It is a controversial subject, and some people will swear by it, and some people will swear at the fabric slipper. We have had quite a number of fabric applications that have proven very successful.

A. E. Cichelli: Does anybody have a successful way of lubricating a slipper bearing?

In the enclosed type you spoke of seals holding in the water. It seems to me the principal function of the water is its cooling effect. How well do you dissipate the heat, if everything is enclosed?

R. L. Berry: There is a positive supply and removal. There are two sets of holes, the water goes in one set and goes out the other.

A. E. Cichelli: I understand that you have something to hold the water in?

R. L. Berry: The water is held in the contained neck, but not continuously.

A. E. Cichelli: What about rusting? How do you prevent rusting?

R. L. Berry: That can be done one or two ways, and that is by the automatic introduction of oil or grease on the shut-down period, or by manually applying it. Wherever you have water, iron and steel together, you are going to get oxidation, and that can be minimized and reduced appreciably by putting a coating on the bearing during the shut-down period.

A. E. Cichelli: On the enclosed type, it seems introduction by use of a positive pressure system is the only way, since it can not be wiped on. It sounds as if there is a problem there.

R. L. Berry: If it is introduced as the mill is closed down, you can go through the bearing and by that way you can protect it.

L. W. Gilchrist: When we do this, we have to be careful as to how much grease, or the amount of grease we use on account of plugging of the sprays, and that was one of our worst conditions. We wanted them free at all times. The only time we used grease was a little on the roll neck when we changed rolls and slipped on the bearings. If we used an excessive amount of grease, we were in trouble with our sprays and also with our drain lines on the bearings. We just stayed away from grease as much as possible on the inside of the bearings.

A. E. Cichelli: Is there any other kind of lubricant that one can use?

L. W. Gilchrist: There is no other kind of lubricant used, just plain water.

I might add a word about the spindle slippers you mentioned in your paper being used on high speed mills.

I have used the sectional type and the ladder type with fair success. The spindles must be kept in good condition and not allowed too much play or they will slap and finally fracture the slipper.

R. L. Berry: When plastics first came out — and this applies to the general field of plastics and not just the laminated plastics — people went hog wild, thinking that they were going to solve everybody's problems. The steel business was going to fold and everything was going to be of plastic.

I am afraid that a lot of us have had an overall approach on slipper bearings, trying them in applications where they should not be applied.

By analysis of the physical characteristics of the material, application, parts, the impact experience, we should be able to know where something should be tried or considered, or where it should not. There are some hot strip mills on which the fabric slipper bearing does well, and there are others where it does not.

I think we could analyze the impacts that you require of the material on the successful applications and by that you would determine that it is either darn close to the limits of the material or over it.

A. E. Cichelli: You mentioned the viscosity of water in connection with designing your bearing. Now, as for clearance determination, do you employ the viscosity of water in the conventional hydrodynamic equations, or is it done by trial and error?

R. L. Berry: I think there is a little divergence in industry as to the possible clearances in using a composition bearing material. We provide no clearance. In other words, the bearing should be of the same inside diameter as the journal against which it is applied. The reason for that is this: with such a set up, you start out initially with an arc contact providing clearance. Otherwise you will start with a line contact, and by that you will get rapid bearing wear until you bring it into an arc contact. On the 360 degree laminated plastic bearings, since the material is contained on the outside, the only way it can expand is inward. This is contraction so, you have to apply clearance there.

Factors Affecting Performance OF HIGH TEMPERATURE GREASES

By ELDON L. ARMSTRONG
Research Associate
Socony-Vacuum Laboratories
Technical Service Dept.
Brooklyn, N. Y.

. . . . field tests are the final criteria for grease performance . . . .

▲ IN the steel industry greases have to function under a wide variety of adverse conditions. On the one hand, the processing of hot steel leads unavoidably to high temperature service. The greases used to lubricate table roll bearings, wheel bearings on hot metal cars and ladles, latch screws on coke oven doors, and sinter conveyor bearings must meet high temperatures as they pass through the machinery being lubricated and are exposed to close-range radiation. On the other hand, the same grease which cannot leak at high temperatures must often be soft and easily pumpable through centralized lubricators at low temperatures. Furthermore, the same grease may be used on a high-speed strip mill or a low-speed machine subject to extremely high pressures. For all these reasons and more, the steel industry is a very exacting customer, and it requires special types of grease for specific equipment.

TEMPERATURE RANGE OF TYPES OF GREASES

Good performance of a lubricating grease at high temperatures requires that the product be stable; the overall stability of a grease being determined by many factors which are interrelated and often complex. They include the resistance of the grease to soften or harden excessively, its oxidation stability, maintenance of a controlled oil bleeding rate, the evaporation characteristics of the oil or synthetic fluid used and others.

Before proceeding with a discussion of these factors which affect the performance of high temperature greases, it is desirable to define the temperature range of use of various types of greases. One such classification is shown in Figure 1. Greases are divided into three types; conventional calcium soap greases, other mineral oil greases and synthetic fluid greases. The temperature range of application for solid lubricants such as graphite and molybdenum disulphide is also indicated.

In Figure 1, the temperature ranges represent maximum levels reached for 1,000 hours of test life in a *non-relubricated* ball bearing. (The maximum temperature range for a given grease will, of course, be higher as the frequency of relubrication of the bearing is increased.)

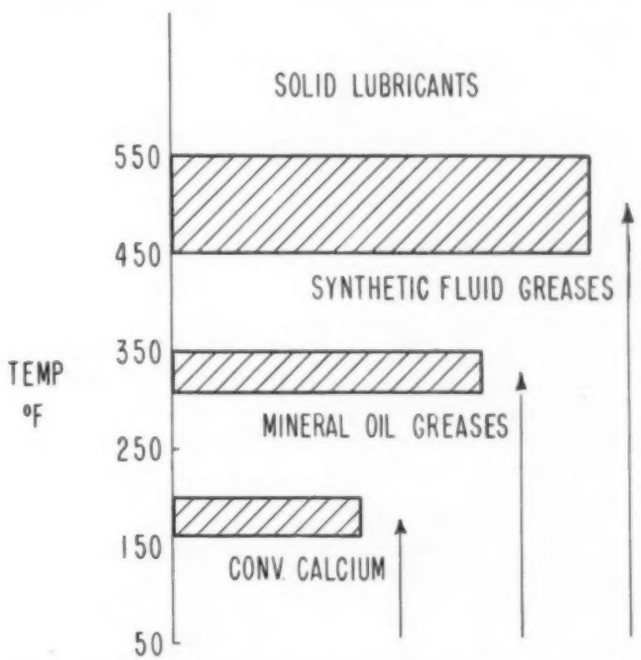


Figure 1 — Chart shows temperature ranges in which various greases are used.

Conventional calcium greases have a top temperature range of use of 160-200 F since at this level, the calcium soap loses its water of hydration and the grease structure is destroyed. Other soap and non-soap greases, containing mineral oils as the fluid, may go up as high

as 310-350 F. At this temperature level or below, the mineral oil may oxidize too rapidly, the soap may dissolve in the oil, the oil may evaporate, or any number of things may happen to destroy the effectiveness of the grease as a lubricant. Synthetic fluid greases have been made covering a temperature range up to as high as 450-550 F. There are many different synthetic fluids, and only one or two silicone greases permit long time operation at the maximum temperature range indicated. Above a temperature of 450-550 F, solid lubricants are required since no fluids have yet been developed to resist evaporation and oxidation at this temperature level.

PERFORMANCE

The performance of a lubricating grease is, of course, determined by its composition. Although the grease may be compounded from 5, 10 or 15 ingredients, the finished product can be considered as a two phase system, a matrix of solid particles dispersed in a viscous fluid. The solid particles are referred to as the thickening agent.

Some of the grease properties, such as structure changes upon working, are mainly dependent upon the size, shape and general characteristics of the thickening agent. Other grease properties, such as evaporation, are primarily due to the type of viscous fluid used. A great many other physical and chemical properties of the grease, such as oxidation resistance, are largely dependent on both the thickener and fluid phases. For convenience in considering all of these properties in more detail, the composition variables and physical and chemical properties are classified as shown in Table I.

TABLE I

FACTORS AFFECTING THE PERFORMANCE OF HIGH TEMPERATURE GREASES

Composition Variables

1. Type of thickening agent.
2. Type of fluid.
3. Type of anti-oxidants.
4. Influence of other additives used.

Physical and Chemical Properties

1. Collodial structure of the thickening agent.
2. Solubility of the thickener in the fluid.
3. Structure changes when the grease is worked and/or stored.
4. Evaporation of the fluid.
5. Oil bleeding.
6. Oxidation resistance of the grease.
7. Effects of contaminants — water, other greases, etc.
8. Lubricating (anti-wear) ability.

COMPOSITION VARIABLES

1. *Types of thickening agents*—Today, it is necessary to divide grease thickening agents into two classes—soaps and non-soaps. Since about 1938, lubricating greases have seen many interesting and sometimes radical changes take place. Soap base greases have witnessed Carmichael and Hain's development (4)* in April 1940 of calcium soap greases containing calcium acetate as a stabilizer for temperatures in excess of 200 F. Zimmer and Morway (22), in December 1941 produced a polymerized soda soap grease for use at temperatures of 300 F and above. In March of 1942, Earle (6) received the first patents on lithium soap greases exhibiting wide temperature range operation. In March 1947, McLennan (15) patented barium, strontium and other types of soap complexes. The above mentioned are but a few of a wide variety of new soap thickened greases which have been introduced commercially. A host of others are buried in the laboratories.

During World War II, the Germans experimented with greases thickened with colloidal silica. Today, we have non-soap greases thickened with hydrophobic bentonite (9), copper phtholocyamine (16), carbon black, water proofed silica, attapulgite and a number of new nitrogen-containing compounds (20). Much research work is in porgress with these and other non-soap gelling agents.

Each new type of thickening agent has created new problems for the grease chemist. The complicated colloidal structures of soap thickened greases are being investigated with the optical and electron microscopes. This work was pioneered by Farrington (7) (8) in 1936. Recently, Browning (3) extracted all of the oil from a grease with selective solvents and observed the meshed structure of the soap thickener. Work of this type will continue, along with X-ray diffraction, differential thermal analysis and other methods. From it will come a fundamental knowledge of soap structures, the phases formed and their transition temperatures. These data will define the performance of the grease from the thickener viewpoint.

The non-soap greases have been limited in their applications, first because of breakdown in the presence of water. To overcome this, the particles were given waterproof coatings. However, then the waterproof greases were deficient in anti-rust properties. When rust inhibitors were added, the thickener became less effective and the grease became softer and less stable at high temperatures. The same is true when extreme pressure agents are used. In addition, the waterproof coatings oxidize at 250 F or higher and the grease gradually cakes up and becomes hard.

2. *Types of fluids*—The types of fluids used in greases are usually classified as petroleum or synthetic. Greases containing non-petroleum fluids have been termed synthetic greases. However, since it was pointed out that either soap or a non-soap thickener can be used, present-day greases fall into one of the following four types:

1. Petroleum oil—Soap type.
2. Synthetic fluid—Soap type.
3. Petroleum oil—Non-soap type.
4. Synthetic fluid—Non-soap type.

Greases containing synthetic fluids were introduced in World War II and the requirements for greases to meet extreme wide temperature ranges have continued to come from the military. The first type of synthetic fluids used were aliphatic diesters (10). Following the diester fluids, we have had the polyglycol types (18), the silicones (11), the silicone-diester blends (17), and the newest are the perfluorocarbons.

* Numerals refer to Bibliography at end of article.

It is believed that for many years in the future, most of our greases will be made from petroleum oil because of low cost, availability and satisfactory performance. Of course, the volume of greases made with synthetic fluids will continue to increase. These synthetic fluid greases are a necessity for extreme wide range temperature use and for delicate, complex equipment which cannot be relubricated.

3. *Types of anti-oxidants*—In general, the additives used in greases are of the same type as those used in oils. They include anti-oxidants, rust preventives, extreme pressure agents, stringiness agents, materials to reduce oil bleeding, coloring agents, fillers, etc. In greases, quite often a higher concentration of additive is used than for oils. All additives will usually have some effect on oxidation stability; other than for anti-oxidants, the effect is generally on the negative side.

Anti-oxidants or oxidation inhibitors are the most commonly used additives in greases. Although much of our knowledge about how they function is still empirical, it is known that the most useful type of anti-oxidant is able to react with one of the products of the oxidation chain reaction and stop it from going further. Metal deactivators are also classed as anti-oxidants, since they form a coating on metals, such as copper and iron, which are oxidation accelerators. The coated metal is deactivated and is unable to participate in the oxidation reactions.

Some commonly used anti-oxidants and their approximate upper temperature limits of use are listed below:

TABLE II

Types of Anti-Oxidants

Type	Approximate upper temperature limit of use (5)
Phenolics	250 F
Aromatic amines	300 F
Dialkyl selenides	325 F
Phenothiazine	350 F

Many problems with high temperature greases will be solved by research for better anti-oxidants. Why a particular type of anti-oxidant is very good in one kind of grease and ineffective in another is a typical example of the unsolved problems.

4. *Influence of other additives used*—Since most of the additives used in greases are of the polar-type, it is quite often found that either they interfere with the action of the thickening agent, or conversely, the thickening agent interferes with the effect of the additive. For example, rust preventives interfere with bentonite and silica greases, as previously stated, resulting in a decreased effectiveness of the thickener and a loss in mechanical and heat stability properties. In lithium greases, the lithium soap often interferes with the action of the rust preventive or the extreme pressure agent, requiring a much higher concentration than would otherwise be used.

Many widely differing types of surface active agents are used in greases as rust preventives. They include amines, sulfonates, naphthenates, esters, etc. An additive which works the best in a sodium soap grease may not be the best in a lithium grease. Each new grease must be tested with a number of compounds and the proper selection made.

Extreme pressure agents are generally used in steel mill greases where heavy shock loading is found, as in rolling mill operations. They may be used in a variety of other greases but it is usually difficult to show the need for them. Generally, extreme pressure agents detract from the oxidation and storage stability of the grease. Extreme pressure additives contain the elements—lead, sulphur, chlorine and/or phosphorus. Lead is usually in the form of a soap, such as oleate or naphthenate. Sulphur, chlorine and phosphorus compounds are made from a wide variety of mineral oil, wax and fatty materials.

Extreme pressure steel mill greases are generally evaluated on the Timken machine and are usually required to carry a minimum load of 33 pounds. The ASTM Committee D-2 is carrying out a cooperative test program to develop a standardized test procedure and establish the reproducibility of the Timken test machine. In the first phase of this ASTM program, a variety of oils were tested and wide variations in test results were obtained (13). It is probable that even a greater spread in results will be noted with greases.

Macdonald and Dreher presented a paper (14) "Additives for Greases" at the 1952 meeting of the National Lubricating Grease Institute in Chicago. They showed some interesting data on lithium greases showing the unusually high concentration of extreme pressure additives required to meet a Timken load of 40 pounds initially. After the extreme pressure lithium greases had been stored for a month, the load carrying rating had decreased down to 25-30 pounds. In this particular grease, an auxiliary agent was required to stabilize the extreme pressure agents in storage in order to maintain the 33-pound minimum rating. Also, experiments in our laboratory have shown a decrease in load rating when certain extreme pressure greases are contaminated with water. In some cases, corrosivity also developed. Thus, the field of grease additives is highly complex. With any additive, one is likely to obtain undesirable side reactions as well as the desired effect.

The other kinds of additives used in greases include fillers, such as graphite, additives to retard oil separation or bleeding, stringiness agents such as polybutene and latex, waterproofing agents such as zinc resinate, dyes to color the grease, etc. They are not used as widely as anti-oxidants, rust preventives and extreme pressure agents.

The preceding paragraphs illustrate that high temperature performance of greases is quite dependent on their composition. The thickening agent, the fluid and the additives must be carefully selected and balanced to obtain optimum results.

PHYSICAL AND CHEMICAL PROPERTIES

Attention will next be directed toward the physical and chemical properties affecting high temperature grease performance. These properties will vary with the composition used and the process by which the grease is manufactured.

1. *Colloidal structure of the thickening agent*—The colloidal structure of the thickening agent refers to the size, shape and general characteristics of the solid particles responsible for the grease structure. These details are best observed by the electron microscope. The techniques required for examination of greases with the electron microscope will not be discussed—except to say that the particles in the grease are usually

cup is reduced to 420 rpm from the normal 800 rpm, the following results are observed with a series of NLGI No. 1 consistency greases prepared in mineral oils ranging in viscosity from 60 up to 1500 Saybolt seconds at 100 F. It is seen that the low-speed OK Timken load rating increased from 20-30 pounds up to 40-55 pounds as the particle size of the thickening agent increased from less than 2 microns up to 50 plus microns.

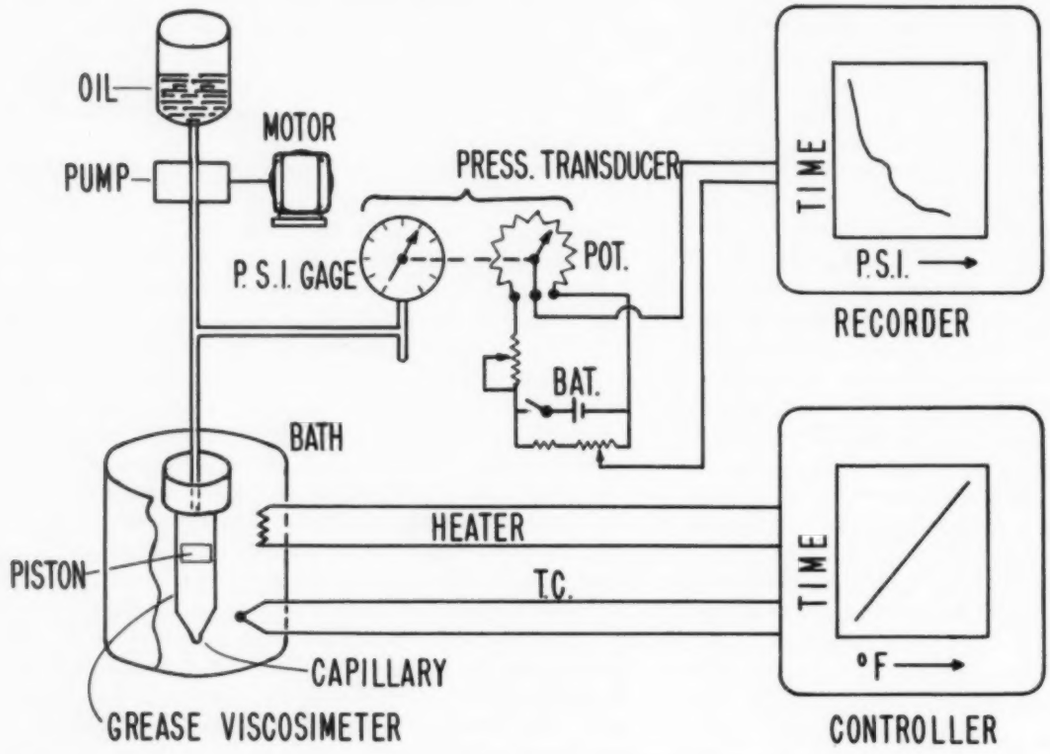


Figure 2 — This high temperature apparent viscometer is used to determine thickener solubility charistics.

washed free of oil and shadowed with a metal coating, such as gold, chromium or uranium, so that the structure of the individual thickener particle may be observed.

The dimensions and properties of the thickener particles are mainly responsible for the texture, consistency and transparency of the grease. In soap base greases, if the soap fibers are longer than about 50 (microns) or 0.050 mm, the grease is quite fibrous. If the fibers or particles are 1 or 2 microns, or less, the grease has a smooth, buttery texture. From a performance standpoint, the longer the fiber, the greater will be the self-feeding property of the grease and its ability to cushion shock loads. A self-feeding grease is often preferred for use in large diameter plain or antifriction bearings having a very long bore. The grease must be able to pull itself through the bearing to prevent the bearing from becoming dry. In some bearing designs, a very smooth, very short fibered grease may be centrifuged away from the bearing path, and not migrate properly through the internal bearing clearances. In other bearing designs, too much self-feeding of a longer-fibered grease results in excessive fluid friction in the bearing and overheating; the grease mass does not channel away from the moving parts of the bearing and is churned excessively.

The load support effect of thickener particle size has been demonstrated in our laboratory by use of low-speed Timken test. If the speed of the Timken test

TABLE III

Low-Speed Timken Tests on Greases — NLGI No. 1 Consistency

Mineral Oil Viscosity, S.U.V. @ 100 F = 100-1500 sec

Thickener particle size	Average size	OK Load range, lb
Small	2 μ or less	20-30
Medium	2 to 50 μ	30-45
Large	50 μ or more	40-55
Extreme pressure greases	.....	70+
St. mineral oil	.....	10-20

The size, shape and concentration of the thickener particles largely determine the grease consistency and transparency. At a fixed concentration, the smaller the particle or fiber, the heavier the unworked penetration of the grease. Also, the smaller the particle size, the more transparent is the grease.

The resistance of a grease to break down when worked is also a function of the geometry of the thickener particles. However, this factor is much more complex than those discussed above and will be discussed under Part 3 of this section.

2. *Solubility of the thickener in the fluid*—The plastic structure of soap base greases disappears at elevated

temperatures because the soap particles dissolve in the oil or fluid. As the soap particles dissolve, the "brush-heap" network and the individual fibers themselves break down until at some elevated temperature, solution is complete, no fibers remain, and the grease is completely fluid. It is, therefore, very important to know the solubility of the thickener in the oil over the expected temperature range of use of the grease.

One instrument used to determine the thickener solubility characteristics is the high temperature apparent viscosimeter (23). A schematic diagram of this equipment is shown in Figure 2. The test grease is filled into a cylinder and is pushed out of the cylinder through a capillary. The hydraulic oil pressure acting on the piston pushing the grease through at a constant flow rate is recorded, as the temperature of the grease is raised at a uniform rate.

A typical curve for a soap base grease is shown in Figure 3. The curve consists of three sections, A, B and C. In Section A, the apparent viscosity of the grease becomes less as temperature rises because the viscosity of the oil decreases with increasing temperature. No appreciable change in the "brush-heap" structure or particle size and shape occurs in this area. In Section B, the apparent viscosity rises abruptly as the first step in solution of the soap particles begins to occur. The first phase of solution is a swelling effect, analogous to the swelling and dissolving of rubber in oil. As a result, the soap particles and "brush-heap" are more tacky and cohesive. The grease, therefore, has a much higher apparent viscosity than before this temperature range was reached. In Section C, swelling has passed the

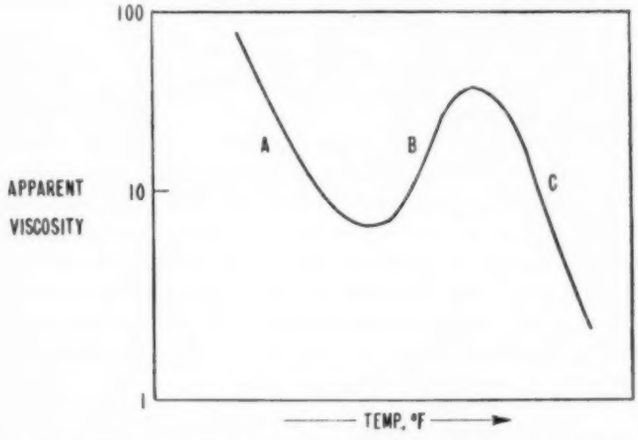


Figure 3 — A typical curve for soap base greases is divided into three sections.

maximum and disintegration and dissolving of the soap fibers is occurring. The apparent viscosity of the grease falls off very rapidly as solution of the thickener becomes complete.

Figure 4 shows curves obtained for a conventional calcium tallow soap grease, a sodium tallow soap grease, a lithium hydroxy stearate soap grease and a calcium soap-calcium acetate stabilized grease. The calcium tallow soap shows a very rapid drop as the temperature exceeds 160 F and water is lost from the soap structure. The sodium tallow soap begins to swell as the temperature passes 260 F, reaches a maximum at 265 F and begins to dissolve as temperature further increases. The lithium hydroxy stearate grease loses viscosity rapidly as the temperature increased above 280 F. The calcium soap-calcium acetate grease has a relatively flat curve over the temperature range from 240 to 340 F.

Data of this type are useful in predicting the maximum operating temperature limit of a grease, above which excessive leakage of the grease from a bearing would be expected to occur.

There are, of course, other factors not evaluated by

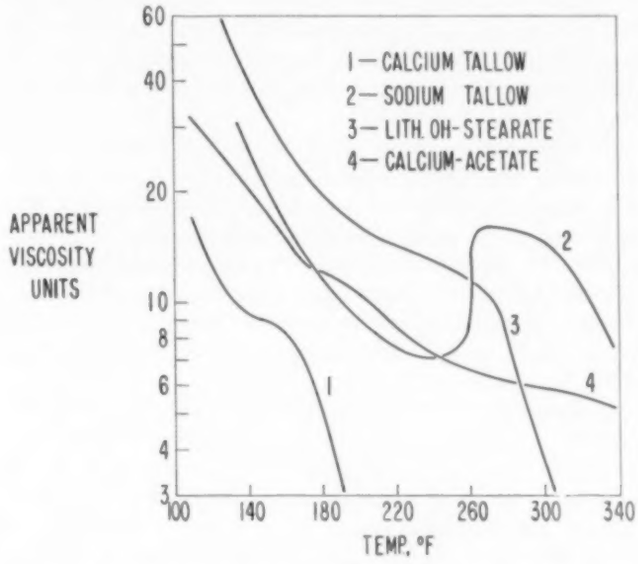


Figure 4 — The apparent viscosities of four high temperature greases are given by these curves.

this type of test which also must be considered. These include oxidation resistance and subsequent change in consistency, the tendency of the oil to evaporate at high temperatures, changes in consistency due to heating, cooling and working the grease, and the bleeding rate over the temperature range. Any of these may make a given grease unsuitable for high-temperature service regardless of excellent temperature-viscosity characteristics.

3. *Structure changes when the Grease is worked and/or Stored*—In practice, if a grease shows too little or too much shear softening in bearings or poor pumpability as a result of stiffening in storage, the grease may be useless although otherwise it has desirable properties. Section IV of ASTM Technical Committee G has been studying and defining these properties (12).

They have developed a method using a simple worker-penetrometer test to measure the shear softening and age stiffening rates of various greases. To determine shear softening, penetrations are taken at 60, 500 and 3000 worker strokes and plotted against logarithm of worker strokes. A straight line is obtained, the slope of which serves as a convenient measure of the shear softening rate. Similarly, the plot of ASTM penetration against logarithm of aging time after working is generally linear and the slope of such a plot serves as a convenient measure of age stiffening rate. The 3000 stroke period in the worker was considered sufficiently long because periods up to 10,000 to 20,000 strokes did not noticeably change the shapes of work softening curves obtained on several greases tried and because periods in the range of 50,000 to 100,000 ap-

peared to cause, in some greases examined, a more destructive and permanent type of softening than is usually associated with shear softening or age stiffening.

The reasons for a grease softening or stiffening are only beginning to be understood. A change takes place in the rigidity of the "brush-heap" of thickener particles. If a loss of rigidity occurs and the grease softens, it is probable that there has been a separation in the "brush-heap" arrangement and/or an orientation of the particles along the direction of the shear plane. If an increase in rigidity occurs and the grease stiffens, it is probably due to the breaking up of small bundles of fibers, or agglomerates of particles, so that their thickening power is improved.

If a change occurs in the "brush-heap," it will have an effect on other physical properties of the grease, such as oil bleeding rate, consistency, texture, etc. Consequently, this matter of structure changes when the grease is worked and/or stored has an important bearing on the overall grease performance characteristics. Further studies of particle aggregation and orientation are needed to improve our general knowledge of grease structure changes.

4. *Evaporation of the fluid*—Where antifriction bearings are operating at high temperatures for long periods without renewal of the grease charge, the factors of evaporation, oxidation resistance and oil bleeding play a major role in performance.

To determine the evaporation loss, a sample of the grease is placed in a closed evaporation cell. The cell is immersed in a high temperature bath at the test temperature. Heated air is passed over the surface of the grease and the evaporation loss is calculated from the loss in weight of the sample. This is the method described in ASTM D972-51T. Another method consists of determining both evaporation and bleeding by suspending a wire filter cone, filled with grease, in a beaker which is placed in an oven.

Evaporation of the fluid from the grease results from volatility of the original fluid components and/or from decomposition of the fluid into volatile products during its oxidation.

When a grease is exposed to a high temperature for a long time, its oil content decreases. Since a grease is an oil storehouse for bearings, as Wilcock and Anderson have described it (21), the grease will fail to lubricate properly when an excessive amount of oil has been lost from the grease structure. Recently, Baker, Jackson and Booser (1) made a study of failed ball bearings from laboratory testers and found that about 80 per cent of the failures occurred when the oil content of the grease had decreased to the range of 37-67 per cent by weight.

TABLE IV

Evaporation Tests at High Temperatures (AN-G-3 Technique)

Type of fluid in grease	Temperature, F at which evaporation loss exceeds 10 per cent after 1000 test hours
Silicone oil	350-400
Brightstock — 150 sec @ 210 F	300-320
Diester	230-250
Neutral — 300 sec @ 100 F	180-200

Typical evaporation results for greases made from a variety of fluids, both synthetic and petroleum oil, are shown in Table IV.

These data indicate that evaporation has a critical part in establishing the high temperature life of a grease. Tests on a number of greases show that at high temperatures about one-fourth of the oil content loss is due to evaporation.

5. *Oil bleeding*—The relative importance of oil bleeding versus evaporation varies with different types of greases. Practically all synthetic greases show low bleeding rates and, therefore, evaporation rate is the more important (2). For petroleum greases, the bleeding rates are considerably higher than for synthetic greases. The bleeding rate for petroleum greases consequently assumes more importance. However, with petroleum greases, it is important to determine the nature of the material which is bleeding from the grease structure after a long exposure to high temperatures. For example, when oxidation has occurred to the point where the oil, bleeding from a petroleum grease, resembles a thick tar or a hard resin when it is cooled, then the useful life of the grease is about over, regardless of the oil bleeding rate or other factors.

It has been found that for silicone and diester type greases there is generally a good correlation between bearing life tests (2) and the bleeding and evaporation characteristics of these greases. However, for mineral oil and polyalkylene glycol greases, the results of bleeding and evaporation tests do not correlate very well with bearing life test data. For mineral oil and polyalkylene glycol greases, the oxidation resistance of the grease is equally or more important than the evaporation and bleeding characteristics.

Up to this point oil bleeding has been discussed primarily from its importance in affecting the life of the grease in bearings running at high temperatures, which are not relubricated very often. Oil bleeding is also important at ordinary temperatures when grease cups or automatic lubricators are used to apply the grease. In this case, separation of oil occurs as a result of a filtration action and may, if the bleeding rate is high, leave behind a soap residue which would plug up the lubricator. Tests to determine this property of a

TABLE V

Effect of Soap Type and Oil Viscosity on Oil Bleeding Rate

No.	Soap type	Average fiber size	Worked penetration	Hours at 70 F to bleed 10 per cent oil
	Mineral oil — SUV @ 100 F = 105 sec			
1	Sodium	50+	296	11
2	Calcium	1	305	34
3	Aluminum	0.1	313	62
	Mineral oil SUV @ 100 F			
4	Calcium	105 sec	254	47
5	Calcium	285 sec	257	103
6	Calcium	850 sec	255	245

grease are run in the separability tester (19). The type of soap or thickening agent used and the properties of its "brush-heap" structure have a noticeable effect on the separation or oil bleeding rate. This is shown in Table V. When greases numbers 1, 2 and 3 are prepared in a 105 sec @ 100 F mineral oil to approximately a 300 worked penetration, the amount of oil loss is directly related to the size of the soap fibers. Greases No. 4, 5 and 6, all made with the same calcium soap, show that as the oil viscosity is increased, the oil bleeding rate decreases. Thus, in general, the smaller the particles for a given grease consistency or the heavier the fluid viscosity, the slower will be the bleeding rate.

6. *Oxidation resistance of the grease*—As previously pointed out, a good high temperature grease is made from a careful choice of thickener, fluid and anti-oxidant. Oxidation resistance is important for long operating life in anti-friction bearings and for long shelf storage life. The ASTM bomb oxidation test (ASTM D942-50) is extensively used and reasonably predicts a grease's shelf storage life. It is much more difficult to predict the operating life of a grease. High temperature bearing testers are used for this purpose. Typical of these are the so-called "Navy testers" as specified in VV-L-791d Method 33.1. Tests of this type are only indicative and cannot be used for a direct calculation of actual service results. For example, the life of the grease is not only influenced by the test temperature, but by such factors as bearing selection, agitation of the grease by vibration, contact of the grease with the various metals which may have a catalytic effect, housing design, speed, load, etc. In a recent series of high temperature tests on a silicone fluid-soap type grease, it was found that a change in the spindle design and housing had a pronounced effect on the grease life. For example, with the old design the grease had an average life of about 400 hours, with individual runs varying from 20 up to 825 hours. With the new design, the grease had an average life of 710 hours, with individual results varying from 382 up to 1034 hours.

It is necessary, in testing the performance life of greases, to use a statistical approach since it is always found that there are considerable variations between individual results of the same test with the same grease. This occurs despite the utmost care in design, selection and maintenance of the equipment.

It, therefore, follows that the selection of an optimum blend of thickener, fluid and anti-oxidant is generally a long time laboratory project.

With the wider use of laboratory functional type tests to develop, screen and compare new products, it becomes increasingly important that the test results be correctly interpreted. With the complexity of factors determining a grease's performance, it is unreliable to use laboratory tests alone as a true measure of a grease's merits or limitations. For this purpose, only a field test under actual service conditions can be expected to give the correct rating.

7. *Effects of contaminants*—Water is the "universal" contaminant most frequently encountered. Since this paper is concerned primarily with high temperature performance at temperatures above 200 F, it is assumed that water will not often be a factor affecting the grease life. It must be stated, however, that the ability of a grease to resist washout from bearings and its corrosion prevention properties are both closely related to its water resistance characteristics. These may be controlled by the selection of thickener, oil and additives to obtain the desired degree of protection.

In high temperature service, the grease is frequently contaminated with used grease of the same brand, new grease of a different brand, dirt, acids, etc. Since, as has been shown, a new grease represents a formula developed to contain definite percentages of a carefully selected list of components, it follows that mixing of greases and contamination with foreign materials will normally result in a decrease in performance. However, contamination must usually be tolerated because precleaning of bearings is frequently impractical. A new ASTM subsection has recently been established to study this problem of "compatibility of greases."

8. *Lubricating ability (anti-wear)*—To be effective, the grease must be able to prevent wear of the surfaces of bearings, cams, screws, guides, and other lubricated parts. Petroleum oil—soap type greases normally have good lubricating ability. Of the synthetic greases, the diester greases give good results. The silicone greases do not give good results when steel-on-steel is involved, unless under very mild conditions. The silicone grease

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is generally satisfactory when bronze-on-steel is used.

The military services have developed the Navy gear wear tester to evaluate the anti-wear properties of greases for use in aircraft instruments and control devices. This tester uses a pair of spiral instrument gears, which are oscillated, under load, through a 360 degree arc. Specification MIL-G-3278 requires that a grease show less than 2.5 mg weight loss of a brass-stainless steel gear combination per 1000 cycles of oscillation with a pound load and less than 3.5 mg loss per 1000 cycles with a ten-pound load. Due to the design of this tester, greases are favored which have a soft consistency. Stiff greases do not slump and feed properly to the test gears and often show early test failures.

Numerous other laboratory testers are used to rate a grease's lubricating ability. Since the mechanical features of the test machine have an important effect on the result obtained, it is very difficult to correctly interpret the data obtained. Here again, field tests must be used as the final criteria of the grease performance.

DISCUSSION

PRESENTED BY

WILLIAM E. ELLIOTT, Lubrication Engineer, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.

G. H. LINK, Staff Engineer, Lubricants Div., Shell Oil Co., New York, N. Y.

J. A. MARLAND, Vice President, W. A. Jones Foundry and Machine Co., Chicago, Ill.

D. E. WHITEHEAD, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

ELDON L. ARMSTRONG, Research Associate, Socony-Vacuum Laboratories, Technical Service Dept., Brooklyn, N. Y.

William E. Elliott: In the steel industry, there are a number of applications for the use of high temperature greases. In the majority of cases it is used as an insurance where bearings may fail due to overloads or some other abnormal condition which results in excessive temperatures. On the other hand, we are also faced with the lubrication of equipment that is constantly operating under high temperature conditions. A typical example of a constant high temperature application are pellet wheel bearings on a sintering machine. This application requires a stable grease which has good pumpability characteristics. The design of the pallet wheel assembly has a great deal to do with the life of the bearings. The most important part of this assembly is the grease seal. I am quite certain that in many cases the grease has been blamed for the difficulties encountered whereas the actual cause of bearing failures was the grease seal. When the seal deteriorates, the grease in the bearings serve as a binder for the fly ash forming a very good abrasive compound and by the same token grinds out the bearings.

G. H. Link: Since "factors" affecting the performance of high temperature greases are basic and pertain to all greases, the paper, of necessity, to be complete, had to be "all inclusive." Before commenting on the paper itself, I would like to suggest that, since Mr. Armstrong has put forth so much effort in research and study and covered the general subject of grease performance so thoroughly, this paper be used as a basis by interested technical organizations to secure a list of papers discussing and elaborating on the many subjects only mentioned in the paper. The paper is so well laid out that these subjects are automatically suggested as one reads the paper. For example, a detailed discussion on "Temperature Range of Types of Greases" could well be expanded into a complete and full sized technical paper.

Moving on to the paper, I would like to point out and discuss a few statements where, in my opinion, there exists a possibility of erroneous conclusions which I am sure the author is equally anxious to avoid.

The last sentence of the introductory paragraph states, and I quote:

"For all these reasons and more, the steel industry is a very exacting customer and it requires special types of grease for specific equipment."

This statement could be interpreted to mean that the author is arguing for the now obsolete special purpose approach where a different grease is recommended for every single application. I am sure the author does not mean this because in the sentence immediately preceding the one in question he states, and again I quote:

"Furthermore, the same grease may be used on a high speed strip mill or a low speed machine subject to extremely high pressures."

In the sentence preceding that he says:

"On the other hand, the same grease which cannot leak at high temperatures must often be soft and easily pumped through centralized lubricators at low temperatures."

Please note the words "same grease."

Therefore, it is self-evident that the author recognizes the fact that the steel industry requires greases which will operate over an extremely wide range of applications and operating conditions. In other words, the steel industry requires the best possible multipurpose greases.

Proceeding on into the paper under the heading "Composition Variables" and specifically referring to the last paragraph under "Types of Thickening Agents," the author states:

"The non-soap greases have been limited in their applications, first because of breakdown in the presence of water. To overcome this, the particles were given waterproof coatings. However, then the waterproof greases were deficient in anti-rust properties. When rust inhibitors were added, the thickener became less effective and the grease became softer and less stable at high temperatures. The same is true when extreme pressure agents are used. In addition, the waterproof coatings oxidize at 250 F, or higher and the grease gradually cakes up and becomes hard."

While I agree in general with this statement, I wish to emphasize that it is possible to formulate non-soap greases which compare very favorably with soap base greases with respect to water resistance and rust protecting properties. Furthermore, American industry had been successful in surmounting many, much more

difficult problems that I am willing to admit are suggested in the paragraph in question.

Continuing under the subheading "Influence of Other Additives Used," the author states:

"For example, rust preventives interfere with bentonite and silica greases, as previously stated, resulting in a decreased effectiveness of the thickener and a loss in the chemical and heat stability properties. In lithium greases, the lithium soap often interferes with the action of rust preventive or the extreme pressure agent, requiring a much higher concentration than would otherwise be used."

Again, the author points out that these are only examples. I only wish to stress that these statements need not necessarily be true in all cases. I have already covered the first statement regarding bentonite and silica greases.

In reference to the statement regarding lithium greases, there are today and have been on the market for several years now lithium base extreme pressure greases, notably lithium 12-hydroxy stearate EP greases, which consistently give a Timken O.K. value of 43 pounds plus, maintaining this high extreme pressure value even in extended periods of storage.

Compared to a conventional calcium base extreme pressure grease made with the same viscosity mineral oil, a lithium 12-hydroxy stearate grease gives typical Timken O.K. values of 48 to 53 pounds with 25 per cent less total of the same extreme pressure additives required to give typical Timken O.K. values of 38 to 43 pounds. The lithium and conventional calcium greases are commercially available today. Please note, I do not quarrel with the statements, only with the possible erroneous conclusions which might be derived therefrom. Continuing under the same subheading in connection with the statements on extreme pressure agents, reference is made to a paper "Additives for Greases" by Macdonald and Dreher, stating:

"They showed some interesting data on lithium greases showing the usually high concentration of extreme pressure additives required to meet a Timken load of 40 pounds initially. After the extreme pressure lithium greases had been stored for a month, the load carrying rating had decreased down to 25-30 pounds."

Quoting from the original paper, it states:

"It is particularly difficult to obtain high Timken film strength values in the lithium base greases and also to obtain values which do not decrease as the greases age."

This statement, I contend, is not true for all lithium base greases. I have already covered this point above but would like to add that enough history has been developed in this connection to completely refute the statement which obviously was made concerning a special lithium soap grease, which composition was not disclosed in either the original paper or in this paper.

In closing, I wish to point out that the author has not overstressed the complexity of grease composition as it affects performance and that it behooves everyone, user and manufacturer alike, to refrain from specifying composition such as thickener, oil viscosity, type of additives, etc., but rather to clearly state application and operating conditions allowing the supplier a free hand to do his best in providing a suitable grease. There is no objection to stating performance levels in terms of standard tests, such as Timken values, Navy rig tests, etc., whenever these tests serve a purpose.

In so doing, not only will you, the user, be assured that you are receiving the best grease the supplier has, but you will be providing an ever present incentive to continued research and improvement of greases.

Joseph A. Marland: What Mr. Armstrong has emphasized, pertaining to high temperature greases, was very clearly presented. I join with the other commentators to say that this kind of work should be encouraged, not only on the individual level, but looking behind what Mr. Armstrong has done, by the producing organization spirit which permits and encourages this kind of study. By approaching the problem with as broad a consideration as possible, so as to offer a product that is widely available and with stability to perform the required function of protecting the high temperature bearing surfaces, not only against deterioration from abrasion or frictional wear, but against entry as far as possible of foreign matter, careful attention should be given also to the problem in the design of high temperature bearings.

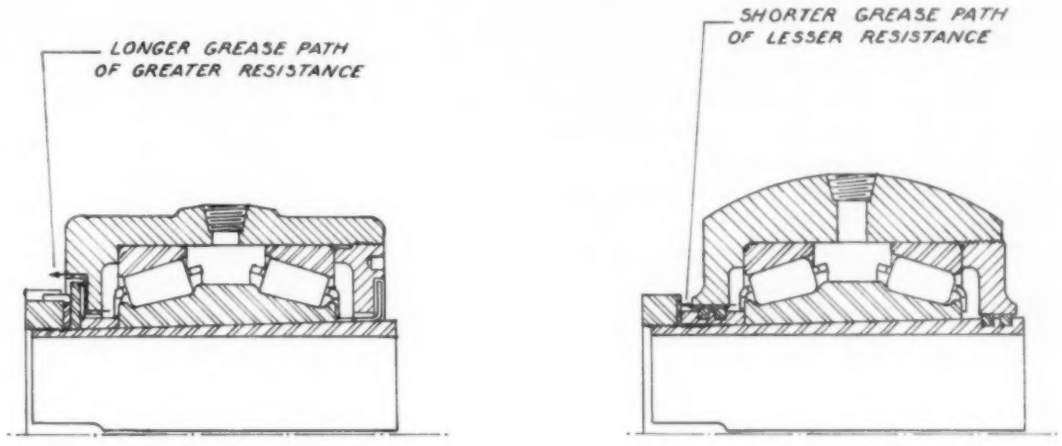

Figure 5 — The labyrinth seal provides greater resistance to lubricant leakage.

I would like to point out that in a sliding friction bearing, where a journal rides closely on supporting surfaces, only a very small volume of free space occurs in such bearings. With temperature changes such as occur in the example cited by Mr. Elliott from Edgar Thompson Works of the United States Steel Corp. on the sintering machine, the pallet wheel bearing has not much opportunity for the atmosphere temperature-pressure balancing action to draw in an awful lot of abrasive material during expansion or contraction of this small amount of air in a plain bearing.

But when we consider a rolling friction bearing such as is frequently employed in pallet wheels, the larger internal housing space occurring in such a bearing provides a volumetric value in frequent and greatly enlarged expansion and contraction with wide temperature range changes to draw in foreign matter that may be immediately adjacent to the ends of the bearing.

At this point a little detail as the type of seal, which Mr. Elliott mentioned, is seriously important in its effectiveness by keeping the lubricant in and by keeping foreign matter out. Mr. Elliott pointed out that they tried metallic seals. I do not know if the reference was made to a specific type of seal as to piston ring or labyrinth design, but our experience has been something like this. If we interpose a relatively long passage, a tortuous pass such as provided in a labyrinth seal, by employing a stationary annular plate in the bearing end cavity and then having a movable shaft attached annular plate, and perhaps even another stationary element followed by a second moving plate, so that the path of grease that enters from the bearing housing into the labyrinth is tortuous, and relatively long, resistance to air pressure change will help keep the contaminating material out of the bearing. See Figure 5. This would help to promote the high temperature grease stability by elimination of moisture or any other contaminating matter during each phase of temperature-pressure change. Such phases are continually recurring on sintering machine pallets and similar equipment where continuous operation, in and out of the highest temperature zone, includes atmosphere pressure changes in the bearing spaces. Of course, if contaminants enter the lubricant chamber, they just veto the particular high temperature stability benefits which have been studiously provided by the lubricant supplier. Depending on the nature of the contaminants, and the degree of temperature variations, the grease may even be subject to catalytic changes.

The comparison of piston ring versus labyrinth metallic type seals may be of interest at this point. If we follow through the shortest possible path of pressure release, as shown on Figure 5, we will find a relatively short lubricant shear area is offered by the piston ring which may permit rupture at any point around its circumference. Even if a multiple ring construction is employed, this same "short circuit" path prevails. By comparison, the labyrinth seal provides a much larger resistance in lubricant shear area. This is obviously an advantage to the labyrinth type of metallic seal in maintaining more resistance to atmospheric pressure changes which tend to occur in rolling friction bearings.

Other mechanical design features which may help to reduce bearing temperatures and thus help the lubrication engineer, include radiant heat shields or discs on the shaft between pallet and wheels. Also, increased space between the pallet and wheel may be helpful in reducing the bearing temperature, although this may require an enlarged section of the supporting shaft at the pallet junction, with tapered diameter to the bearing to adequately support the load without undue stress. Such careful study should, of course, be made in the design stage on new sintering plants.

D. E. Whitehead: You mentioned in your paper that certain inspections were made in order to prevent the use of silicone greases contacting stainless steel. I am very much interested in that statement. Would you care to elaborate?

William E. Elliott: Specification MIL-G-3278 covering a general purpose aircraft and instrument grease containing diesters, includes a gear wear test. The test apparatus consists of a small brass and stainless steel helical gear combination, driven with an oscillating motion. Silicone greases show high gear wear rates on this test.

D. E. Whitehead: Is that abrasion or chemical reaction?

Eldon L. Armstrong: That is primarily abrasion. It is abrasion of the brass, not of the stainless steel.

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Steel Mill Lubrication Problems

. . . . cooperation between the oil and the steel industries has helped solve many plant lubrication problems . . . .

By A. C. KEISER, JR., Supervising Lubrication Engineer, The Texas Co., Birmingham, Ala.

E. E. PERSO, Supervising Lubrication Engineer, The Texas Co., Los Angeles, Calif.

W. H. MANDY, Engineering Representative, The Texas Co., New York, N. Y.

M. S. CLARK, Chemist, Technical and Research Div., The Texas Co., New York, N. Y.

▲ IT has been said that lubricants in steel mills must function under a greater variety of adverse conditions than in any other industry. These conditions must be considered not only when the lubricants are being selected but also when they are applied. Small wonder it is that steel mill lubrication engineers, men distinguished by their competence and versatility in coping with unusual situations, enlist the aid of their lubricant suppliers in developing or recommending products especially suited for severe conditions such as the following:

Water—Whether from high pressure descaling streams, copious floods in hot roll cooling, dispersants for cold rolling fatty oils, or condensate from steam or atmospheric moisture, water is an ever present problem. Not only does it tend to displace or wash the lubricant film from bearing surfaces, but water contamination may seriously impair the functioning of enclosed lubricant systems. Oils, for service where water entry is likely, must possess and retain the property of rapid separation from aqueous mixtures. This latter quality is not adequately measured by the Herschell demulsibility test but is determined better by actual water separating ability in the oil reconditioning system.

Scale and dirt — Iron and slag particles, ranging in size from fine sheet oxides, upwards through blast furnace dust, coal and cinder breeze, to sizable chunks of mill scale are constantly surrounding and sifting into lubricant systems. This will cause direct damage from abrasion as well as less apparent catalytic deterioration of the lubricants. The lubricant supplier spends millions of dollars in modern refining equipment in order to produce a pure, clean and stable lubricant, yet this product, if sufficiently contaminated with mill dirt, may be completely ruined.

TABLE I
Adverse Conditions

Steel mill unit	Contaminants: Water	Contaminants: Mill scale	Contaminants: Roll oil	Other unfavorable conditions
Hot strip mill bearing system	1	2	..	Temperature from heated slabs or strip
Cold strip mill bearing system	..	2	1	Starting up pressures (Cold reduction)
Backup roll bearings	..	1	..	Starting up pressures (Temper mills)
Reduction gear sets	1	2	..	High speeds
Enclosed table gears	1	2	..	Temperatures
Open table gears	2	1	..	Temperatures, speeds
Mill screws	2	1	..	Loads

1 — Most troublesome. 2 — Next in severity.

TABLE II
Adverse Conditions

Steel mill unit	Contaminants: Water	Contaminants: Mill scale	Contaminants: Roll oil	Other unfavorable conditions
Plain roll neck bearings	1	2	..	Temperatures, loads
Universal spindle couplings	..	..	..	Centrifugal force
Blast furnace tops	2	1	..	Toxic gases, flue dust
Air compressors	..	1	..	Dirt in intake air
Wire cables	2	1	..	Rough handling
Turbo-blowers	1	2	..	Condensate from turbine

1 — Most troublesome. 2 — Next in severity.

Heat — High temperatures transmitted from hot metal processes are inherent to the steel industry. This primary heat, as well as that internally created by friction, makes necessary the use of thermostable oils and greases for bearings operating in the hot areas.

Cold — Lubricants are often called on to be soft and easily pumpable through centralized system lines at temperatures around zero F or lower and for distances of several hundred feet.

Loads — Equipment to produce the vast pressures required in the rolling and shaping of steel must itself be strong and heavy. Lubricants for steel mill machinery in turn must be able to protect heavily loaded bearings and gears when mills are just starting up and also when under full or overload running conditions.

Speeds — In the continued drive for more steel production, the past year's records become this year's bases. Mills are speeded up, greater reductions are made per pass, down time is held to a minimum. Each speed increase imposes a more severe demand on the lubricant.

Severity cycle — Practically all mill moving components are subjected to one or more of these adverse conditions, as tabulated on the accompanying Tables I and II. The cumulative effect results in a cycle of events increasingly unfavorable to good lubrication. Simplified to include three principal stages, this cycle may be diagrammed as shown in Figure 1. A new or newly overhauled mill is represented by Stage 1. Bearing seals are tight, effectively preventing entry of dirt and water. Mill operators are alert and especially careful in following safe procedures. Under these optimum conditions of reasonable speeds and roll pressures, the lubricants function well. Oil systems remain uncontaminated, grease systems operate efficiently, and the bearings thus adequately supplied and lubricated give good service.

In time, made shorter when management and operators seek to increase output by pushing the mills and deferring maintenance, bearing wear increases and seal clearances widen. Contamination begins to be a problem; consumption of oil increases as leaks develop. Stage 2 of the cycle has been reached, although properly designed and operated filtering systems may still keep the circulating oil in shape.

Sometime later the accelerating effect of time, speed, cost cutting, neglected maintenance, and stepped up rolling pressures produces the final Stage 3. Worn or damaged seals allow infiltration of water, roll coolant, and mill scale at a rate more rapid than they can be settled or filtered out. Oil and grease passages and lines may become clogged with lubricant which has become deteriorated from excessive contamination or from heat. Bearings now wear, wipe or freeze with increasing frequency due to impaired lubrication. Mill output begins to drop along with product quality.

Finally, when excessive repair costs threaten production it is necessary to shut down the mill and give it a much needed overhaul. Then the rejuvenated mill is ready to start Stage 1 of the severity cycle all over again.

Fortunately, in actual operation the entire mill is rarely allowed to wear out as far as Stage 3, but the cycle is evident and disturbing to the maintenance group who would like to keep the equipment in good operating shape.

Steel mill machinery, by the nature of the work involved, is very heavy, but at the same time it must give precision performance especially in rolling where gages of small fractions of an inch must be maintained. For these reasons the steel industry requires special types of lubricants for specific equipment.

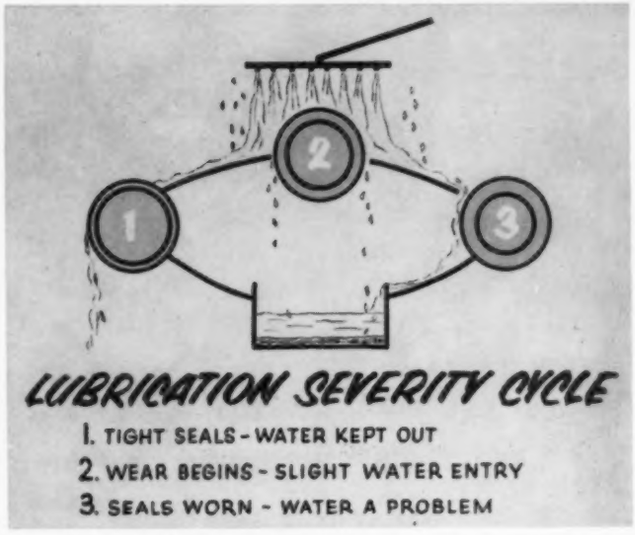


Figure 1 — Maintenance must be done when lubrication conditions reach stage 3 of the severity cycle.

Most of these lubricating problems are different from those encountered in other industries. Some of the problems have existed for decades and there seems to be no solution but operators have learned to live with them while trying incessantly to improve the operating conditions.

It is the purpose in the remainder of this paper to discuss a few of the more prominent steel mill lubricating problems and to point out some of the methods of solving them, which have been developed over years of practical experience in the mills.

WATER AND MILL SCALE CONTAMINATION OF HOT STRIP MILL BEARING OIL SYSTEMS

Well refined circulating oils (2000 to 2500 SSU viscosity at 100 F) are usually recommended for lubrication of sleeve type backup roll bearings of hot strip mills. These oils should have good oxidation stability and good water separating qualities. They often become contaminated with water and mill scale, forming stubborn emulsions which are difficult to break. Water from high pressure descaling sprays and from roll cooling sprays leaks past the seals and carries with it fine iron oxide particles from the strip. This material can be so fine that it passes through pressure filters and remains suspended in the oil.

In many hot strip mill circulating systems emulsions begin to form within two or three days after the mill goes into operation on a batch of oil. Emulsions usually show a brownish oil discoloration at first, but as the amount of water increases they gradually turn to a pale yellow.

It has been observed that as soon as the emulsions appear, less water drops out in the settling tank and the water content of the oil climbs rapidly. The circulating pump seems to "homogenize" the water with the oil and stabilizes the emulsions.

Solution — The obvious solution to this problem is to keep the water and mill scale out of the oil systems.

SMALL QUANTITY RECIRCULATED HAS ONLY FEW SECONDS FOR SETTLING
INCOMING OIL
OIL LEVEL
WARM INCOMING OIL TAKES DIRECT PATH TO OUTLET
COOL DORMANT OIL

Figure 2 — Chart shows flow of oil in a settling tank without baffles.

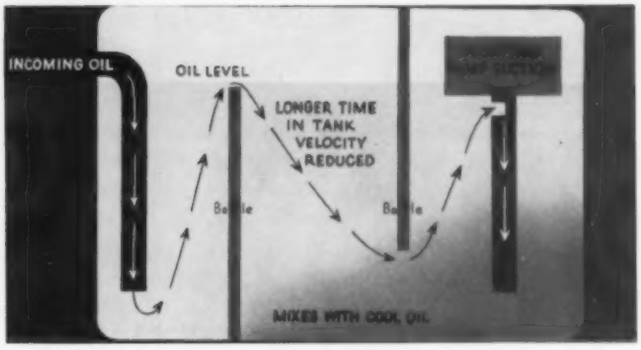


Figure 3 — Chart shows flow of oil in a settling tank with two baffles.

This is being accomplished to some extent by the use of more effective bearing seals; avoiding damage to seals during installation; and constant vigilance to detect and renew worn or damaged seals. Water legs, installed in the oil return line from each roll stand enable the operator to determine which bearings are admitting water.

It is practically impossible to prevent some contamination, hence it becomes necessary to provide rather elaborate reclamation systems to quickly remove such contaminants before they form stable emulsions.

A typical oil circulating system for a hot strip mill consists of two large settling tanks equipped with heating coils, one or more oil coolers, a pressure type filter, two circulating pumps equipped with pressure gages, and a low pressure alarm, and one or more centrifuges equipped with auxiliary heaters.

If satisfactory results are to be obtained, it is advisable to observe the following precautions in the selection and operation of the oil circulating system:

1. Provide settling tanks of ample size and proper design, giving due consideration to the fact that in reclaiming a batch of oil containing water, considerable foaming will occur when heat is applied, hence it is common practice to hold the oil level at three-fourths of tank capacity. It should also be remembered that the quantity of oil in the operating tank governs the available time for the incoming oil to drop out contaminants before it is again pumped into the bearings.

   Two of the prerequisites of efficient gravity settling are slow movement of oil through the tank, and adequate heat to lower the viscosity sufficiently to enable quick settling of water and mill scale. Vertical baffles in the settling tank are desirable to reduce the rate of flow and provide thorough mixing of the incoming oil with that in the tank, otherwise, a small percentage of the oil in the system will be recirculated over and over again while the bulk of the oil will lay undisturbed near the bottom of the tank. Figures 2 and 3 show the advantages of baffles in settling tanks.
2. Install heating coils in a vertical or steeply inclined position rather than in a horizontal position near the bottom of the tank. This permits quicker and more uniform heating of the oil when batch treating the spare tank of contaminated oil.
3. Provide sufficient oil cooling capacity to enable the operator to maintain a high temperature in the operating tank thus reducing the oil viscosity for better water separation. Since the temperature of the oil supplied to the bearings must be maintained at 100 to 105 F, it is usually necessary to hold the operating tank temperature below that required for proper water separation because of inadequate cooler capacity.

   Many hot strip mills are compelled to operate with oil temperatures of 110 to 120 F in the settling tank. Table III shows that a 2450 SSU at 100 F oil has a viscosity of approximately 1500 at 115 F. If the operating tank temperature could be increased to 150 F, the viscosity would be reduced to 530 thus affording much better water separation. With many present installations this is not feasible due to small coolers and high cooling water temperature.
4. Provide a sufficient number of centrifuges with plenty of extra capacity in order to remove water as fast as it enters the system. If water is removed quickly there is less chance of forming stable emulsions and the centrifuge can be operated at or near its rated capacity. If emulsions are formed, it will be necessary to increase the temperature of the oil and reduce the flow through the centrifuge for effective results.
5. Alternate the operation of the two storage tanks every week or ten days; one containing clean oil is placed in operation and the other is removed from service for batch treatment. When, due to inadequate facilities or improper operation of the reclamation system, the oil becomes emulsified, it is advisable to change tanks before the emulsion becomes too stable. If batch treatments of the oil are made frequently, emulsions are more easily broken and water can usually be removed by heating to 180 or 190 F and holding the oil at rest for a few days. The longer the tank remains in service,

TABLE III

Viscosity — Temperature Chart

(Showing the effect of Temperature on the Viscosity of a 2450 second oil)

Viscosity	Temperature, F	Viscosity	Temperature, F
2450	100	530	150
1750	110	415	160
1500	115	330	170
1250	120	267	180
925	130	178	200
690	140	147	210

the more stable the emulsions become and the more heat is required to break them.

Emulsion breakers are frequently used to hasten the batch treatment and to break stubborn emulsions. Considerable care must be exercised to use only the proper amount (usually 0.10 per cent is sufficient) and to get it thoroughly mixed with the contaminated oil. An emulsion breaker should be added slowly in the oil return line to the settling tank or at the pump suction while the mill is operating, approximately eight hours prior to change to the spare tank. The oil should then be heated to 180 to 190 F and allowed to settle 24 to 48 hours, after which water can be drawn from the bottom of the tank.

WATER AND MILL SCALE CONTAMINATION OF COLD STRIP MILL BEARING OIL SYSTEMS

Carefully refined, heavy oils (800 to 2500 SSU viscosity depending on manufacturers' specification) with especially good stability and water separating characteristics are recommended for the lubrication of sleeve type backup roll bearings. In order that the desired quantity of oil may be supplied at the proper temperature as well as be maintained in good condition, modern strip mills are provided with large capacity tanks, circulating pumps, filters and coolers. A spare tank is usually included to allow for rest and treatment of half the oil while the remainder in the other tank supplies the mill.

Although cold strip mills are not subjected to such quantities of water as hot strip mills, they do have greater possibility of contamination with roll oil solutions which usually consist of palm oil or palm oil substitute in water solutions, or soluble oil emulsions.

These solutions often contaminate the lubricating oil systems and if allowed to remain are liable to cause stubborn emulsions very difficult to break. Any fatty oil remaining in the system will greatly increase possibility of emulsion formation if additional water enters the system.

Table IV, comparing principal tests of new and used circulating oil, discloses the changes and nature of the entrained material due to roll solution contamination. Most apparent is the color change from bright clear to opaque brown or even tan due to the emulsified water. The thickening, and flow reducing effect, of the emulsion is seen in the increased viscosity at 100 F. It will be noticed that when filtered, the viscosity drops to a point near the figure for unadulterated lubricating oil.

Fatty oil contamination and oil oxidation products are revealed by the presence of an appreciable saponification number. Pure palm oil has a saponification value of about 200; half the saponification number is equivalent to the approximate percentage present in the circulating oil.

Spectrographic analysis of the ash, showing iron as the major component, is an indication that considerable solid matter is carried in with the roll solution.

Low demulsibility value, or the rate of separation from water mixtures, is another penalty from roll oil contamination and it contributes to the relative permanence of the emulsion.

Solution — Separation of roll oil contamination follows the general procedure previously outlined for water removal from hot strip mill systems. High heating temperatures, sometimes above the boiling point of water in the precipitation tank, and careful centrifuging are needed to separate these emulsions. Emulsion breakers which contribute greatly to hot strip separations seem less effective in the presence of roll solutions.

TABLE IV

Cold Reduction Mill Backup Roll Circulating Oil

	New oil	Contaminated with roll emulsion	
		In use	Centrifuged
Appearance	Green	Tan	Green
Water (by dist) per cent by vol.	0	12.4	Trace
Viscosity, SSU @ 100 F	2450	2900	2271
Precipitation number	nil	1.2	Trace
Neutralization number	0.05 max	0.27	0.35
Saponification number	0	5.5	5.7
Ash, per cent composition, spectrographic	nil	0.33 iron	0.08 iron
Demulsibility @ 180 F	1620	2	2

Fine mill scale, slow to settle in the gravity tanks, is more easily removed in the centrifuge. Unfortunately, separation of palm oil is practically impossible since it is soluble in the lubricating oil. Small amounts of fatty oils and oxidation products may be selectively adsorbed by hot contact clay filtration after all water is removed, although the expense is considered prohibitive for mill operation. Likewise, chilling and filtering, as is done in solvent dewaxing of lubricating oils at petroleum refineries, is beyond consideration.

Ultimate answer to the roll oil contamination problem, then, lies in vigilant attention to bearing seals to prevent entry of appreciable amounts. When water leg traps are systematically checked for water accumulations, leaky roll seals may be quickly detected and marked for attention. How effectively the roll shop personnel inspects seals, replaces those found defective, and how carefully bearing units are reassembled will largely determine how much or how little roll solution will leak into the circulating oil system when the mill is in operation.

UNIVERSAL SPINDLE COUPLINGS

The lubrication of the bronze slippers in universal spindle couplings on rolling mill equipment presents a difficult problem because centrifugal force causes the lubricant to be thrown off and because those equipped with grease fittings cannot be lubricated at frequent intervals without incurring loss of production.

Solution — The problem has been approached from several angles with varying degrees of success but none entirely satisfactory, however, bronze slipper life has been extended by the following methods:

1. Application of very adhesive extreme pressure greases at every opportunity available.
2. Wrapping the coupling with canvas or heavy waterproof paper to retard the throw-off of the grease.
3. Drip feeding an adhesive fluid lubricant on the coupling by means of oil cups or circulating oil systems with or without suitable shields to catch the oil thrown from the coupling.

4. A very practical and most effective solution is used by a large western mill where a 750 SSU at 100 F lead naphthenate extreme pressure gear lubricant is sprayed one minute every half hour on the couplings.

   An air operated barrel pump supplies lubricant to a spray nozzle mounted as close as possible to the coupling. Automatic controls start and stop the pump and admit compressed air for atomization. Air continues to blow through the spray nozzle for a half minute after the pump has stopped. This clears the nozzle and prevents it from clogging. Increased tonnage on the mills is claimed for this method of spindle coupling lubrication due to no "down time" required for lubrication. Replacement of bronze slippers has been reduced 50 per cent or more.

LUBRICATION OF BLAST FURNACE TOPS

Lubrication of bell and distributor systems on blast furnace tops has always been a difficult problem because it was necessary for operators to climb up to the top of the furnace and apply grease from a hand pressure gun. This could be hazardous because of poisonous gases coming from the stack. For this reason two or more men would be sent up in case there was any emergency. Under certain wind conditions no one could enter this area.

Solution — Most modern blast furnaces are equipped with automatic grease systems for lubrication of the bell and distributor mechanisms and many of the older furnaces are being equipped with automatic or manual systems. Points requiring lubrication are tied in with supply lines originating outside the danger spots. Here the oiler may safely lubricate the top of the furnace from a central location.

For such long line systems, pumpability of the grease is an important consideration. If pressure required to move the lubricant is too great the lines may burst, therefore, soft or semi-fluid greases are favored. Non-separation of grease is a required characteristic because of great difficulty in reaching and cleaning out clogged lines.

CONTAMINATION OF LUBRICATING OIL IN TURBO-BLOWER SYSTEMS

The lubricating oil supplied to the bearings and governors of turbo-blowers is subjected to an adverse combination of dirt, heat, moisture and acid atmosphere. Tremendous quantities of air required for the reduction of ore in the giant modern blast furnaces are compressed by these large capacity, high speed centrifugal blowers. Heat of compression of the air and frictional heat result in higher bearing and oil temperatures than are experienced in turbo-generator units. Condensed moisture and settling dust particles from the entering air combine with steam leaks from the turbine to work in past seals to contaminate the lubricating oil stream.

Formerly, under these conditions so much sludge accumulated that it was an unpleasant necessity every few months to drain out the deteriorated oil, shovel out the muck deposits, and renew with fresh oil.

Solution — When superior turbine oils containing rust and oxidation inhibitors were introduced, the oil deterioration problem was largely solved. But with dirt and moisture continuing to enter the lube oil passages, the operators were still plagued by the contamination problem.

In order to reduce the amount of fine air-borne solids in the intake, increasing attention has been given to filters, washers and precipitators. Revolving oil bath filters are available and are reported to be effective and relatively inexpensive to operate. Some operators express fear that sufficient light oil vapors might be picked up by the air stream as to constitute an explosion hazard in the compressor.

While good turbine and compressor seals accomplish much in preventing the entry of foreign matter, there is always a small and often times increasing leakage of material into the oil system. As seals wear, stiffen, or otherwise become less conforming with use, more and more contamination is likely. In addition to its bulk effect, such combination of metallic oxides and other dust may act as a chemical catalyst to accelerate oil deterioration. With the passing of time the lubricating oil becomes so saturated that some of this agglomeration may settle out in the quieter portions of the oil system.

In combating this, a separate filtering system for each blower unit and a small exhaust blower to remove moisture laden vapors above the oil in the reservoir are installed. This has been found effective. In this manner individual differences in behavior may be detected and the filter operated to accomplish the needed cleaning measures.

Generally, in these gravity systems, the oil is first heated to around 150 F to assist in separating entrained water, which settles as the oil percolates around trays. Excessive heating should be avoided. Solids are then removed by passing the oil through bag filters, or filters containing paper or cellulose elements but not active clay filtration which usually depletes the oxidation inhibitors.

Many operators favor water washing as a means of leaching out acidic contaminants picked up by the oil, although there is some likelihood that the water also extracts the rust inhibitors. Before returning to the bearings, or machine base reservoir, as the case might be, the oil is cooled by means of a heat exchanger.

While the ultimate service life of a modern turbine oil given this treatment may be shortened by other influences, there are some Southern steel mill turbo-blower systems where rust and oxidation inhibited oils introduced eight years ago and in continuous service since are still comparable in condition to new oils.

PRESERVATION OF ROLLS IN STORAGE

In rail and structural mills, rolls for less popular shapes or sizes may be stored for long periods between runs. If not protected from the elements, the machined or ground roll surfaces soon rust and deteriorate. Hard drying preservative coatings have been used successfully for outside storage, but these are difficult to remove when the rolls are to be put back into service.

The preservative should have the following qualities:

1. Should be fluid enough for air spray application without having to be heated to reduce consistency or thinned with solvent.

2. A normal film thickness should dry fast enough not to run off.
3. Must provide complete protection to bright roll surfaces when the rolls are stored in the open for long periods of time.
4. Should preferably have a soft film so that scratches would be self healing.
5. Should be easily removed by quick swabbing with petroleum spirits.

Solution — Petrolatum base protective coating materials containing anti-rust agents have been found very effective in preventing rust. These are supplied already reduced with volatile solvents to a consistency easily handled with the usual paint spraying equipment. When the solvent evaporates, a soft non-drying film remains which seals out air and moisture during prolonged storage in the open. Material is easily removed by wiping with mineral spirits.

SELECTION OF PROPER GREASE FOR USE IN CENTRALIZED GREASE SYSTEMS

The conditions under which grease must operate in a steel mill are so diverse and adverse that no single type of grease could possibly handle all the situations. For that reason it is often necessary to have "tailor made" products to meet many of the adverse conditions.

Some of the difficult conditions, along with suggestions for proper types of grease, are shown in Table V.

TABLE V

Adverse condition	Type grease required
1. Low temperatures When it is difficult to pump through long lines.	Usually No. 0 NLGI grade, with a comparatively low viscosity mineral oil, can be handled easily.
2. High temperatures When lines are subjected to high reflected heat and separation occurs in lines.	Water stabilized grease will separate at temperatures above 200 F. If higher temperatures are involved non-water stabilized product should be used.
3. Pressure Continuous pressure on a grease lubrication system may cause slight hardening in lines, metering valves or on strainers. This may at times be sufficient to restrict the flow of grease.	Instability of greases under pressure appears to be tied in with several factors such as: a. Improper manufacture of grease. b. Non-homogeneity of grease structure. c. Materials used in manufacture. There are a few laboratory tests which may show potential tendency of grease to harden under these conditions, but the best method to follow is to rely on grease supplier to provide product which has been designed to handle the particular conditions involved.
4. Excessive temperatures Around 1000 F or higher where ordinary greases burn off in a short time.	Use lubricants blended with solid materials which will remain in bearings after soap and oil have burned off and which will prevent metal to metal contact.

Taking into consideration the tremendous tonnage of steel processed and the multiplicity of lubrication problems involved, it is agreed that steel mill operators and lubrication personnel have shown remarkable ingenuity in handling very difficult situations.

DISCUSSION

PRESENTED BY

ANDREW E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

J. F. BOAL, Lubrication Engineer, Maintenance Committee, United States Steel Corp., Pittsburgh, Pa.

H. H. WOOD, District Manager, Morgan Construction Co., Pittsburgh, Pa.

M. S. CLARK, Chemist, Technical and Research Div., The Texas Co., New York, N. Y.

E. E. PERSO, Supervising Lubrication Engineer, The Texas Co., Los Angeles, Calif.

A. E. Cichelli: One problem, in particular, is the contamination of back-up roll bearing systems. The authors went to great length to tell us what has been done to reduce the water content once it has entered into the system. We are interested in learning what the oil companies are doing to improve their oils' demulsibility characteristics.

All of us agree our problem would be minimized if the initial oils were less susceptible to holding water. We realize that contaminants have a very great deal to do with the problem and that the first step is to keep the water and scale out. But once trouble comes, we feel the oil companies have a responsibility in helping us out by improving the water-separating characteristics of their product.

All of us know that two different oils will not perform the same way in that respect. Since we know that, I am sure the oil companies know it, too. Therefore, it seems to us that they owe us a real program in developing an oil that will separate from water very readily. It would be interesting to learn whether such a program is underway, and if so, how it is being carried out.

As for the emulsion breaker, there are several opinions on its use. If one has to use the emulsion breaker, he must be in real trouble. We prefer not to use it. If it appears we must use it, we look hard for our trouble — to the end that we can cease using the emulsion breaker. We point towards its elimination; we do not like to be in a position where we must rely on its use.

I was interested in the description of a hot strip mill oil system. I did not hear anything about the initial rust protection coating that should be given to the tank and its importance to the longevity of the oil. Very often, equipment builders sell us an oil system whose tank or other component parts are not properly protected. It is our feeling that in hot strip mills, cold strip mills and for that matter, in all types of mills and auxiliary equipment, tanks should be protected internally before the system ever goes into operation. A coating that will last, if possible, the life of the system would be desirable. In our own case, we make use of an aluminum paint in a bakelite vehicle and maybe every five years or so the tanks are cleaned out, coatings are inspected and, where needed, another coat is applied. Unless this protection is afforded, the resulting rust will reduce the life of the oil considerably.

Now, as to the problem of settling and of baffle con-

struction. Since Figure 3 shows a longer path for the oil to travel, it seems to me that the oil is traveling faster, not slower. Perhaps I misunderstood the author. Again, what is your opinion as to the proper settling time?

I wonder if the author would discuss the lubrication of spindle and couplings used in a Western mill in which the lubricant is atomized and sprayed at regular intervals into the coupling from a short distance away.

The paper mentioned turbo generators, and it said that turbo blowers are more of a problem. I do not know about that, but I do want to make a point about the turbo generator system as well as the turbo blower.

If we are so concerned about protecting the interior surface of the tank because of possible condensation and its effect on the oil, why should we not be equally concerned about the drain line? What is being done? It seems to me that turbine builders do not see eye to eye with most of us on that.

J. F. Boal: I would like to compliment the authors on their excellent paper which highlights a number of the most troublesome problems encountered in steel mill lubrication. The problems are presented clearly and accurately and the paper may serve as a valuable guide for mill equipment designers as well as for mill maintenance personnel.

The authors mentioned that as mill equipment grows older it passes through several stages of the severity cycle and that one of the conditions resulting is high lubricant consumption caused by leakage. In much of the equipment in service in steel plants today, high oil consumption is one of the more serious problems with which we are confronted.

A study of oil consumption in larger oil systems in several plants reveals a considerable difference in the per cent of make-up oil required for different types of applications. Oil systems on turbines and large electric motors are quite efficient in the use of oil, averaging less than twenty per cent make-up per year. Pinions and reduction gears on a number of mills averaged about 100 per cent make-up per year.

Mill table and back-up roll bearing oil systems vary considerably in their oil consumption depending upon their condition and the quality of the maintenance they receive. On the several mills investigated, the average make-up oil required for the tables as well as for back-up roll bearings was approximately 300 per cent per year. The worst offenders from the standpoint of oil consumption were the old steam and gas engines where circulating oil systems required 600 per cent annual make-up.

High oil consumption, resulting directly in high lubricant cost, often impels the user to search for the lowest priced oil that will lubricate satisfactorily during the relatively short time it is in the system. Thus, an oil with high oxidation resistance, which quality may have been built into the oil at extra cost by the refiner, shows little advantage over the ordinary quality oils in many high make-up systems.

Reduction in excessive oil consumption in a plant is one of the best methods of keeping lubricant costs in line. The following measures used either singly or combined, have accomplished good results:

1. Maintain records of oil consumption in circulating systems and act promptly to remedy any mill condition that results in a sudden increase in oil consumption.
2. Carry out a good preventive maintenance program on operating equipment with particular emphasis on bearing seals, oil system piping, mill alignment and the like which are known to influence oil consumption.
3. Change from lighter oils to high viscosity, more adhesive, asphalt lubricants where practical in individual gear castings subject to leakage, and particularly those in which excessive water enters the cases and floats out the lighter oil.
4. Training of mill personnel in such specific phases as maintenance of hydraulic systems has also been used effectively as part of an oil conservation program.

H. H. Wood: This discussion will be confined to the portion of the paper covering lubrication problems of totally enclosed flood lubricated metallic roll neck bearings of the precision type. Table I tabulates conditions adverse to successful operation of bearings and lubrication systems in hot mills, in cold reduction mills, and in temper pass cold mills. As stated in the paper, and shown on this table for hot mills, water and scale in that order are the principal problems, but it has not been our experience that temperature from heated slabs nor strip has much of any effect on roll neck bearings or their lubrication. From a lubrication standpoint, hot mill speeds and loads and the combination of the two are no particular problem.

With reference to cold reduction mill installations, Table I lists roll oil and mill scale as contaminants in that order. We believe that water and roll oil, which may be soluble oil, palm oil, or its substitutes, are the real problems to contend with and not much difficulty is experienced with mill scale.

In selecting viscosity of lubricating oil for cold mill installations, it is necessary to consider the combination of heavy separating force loads now carried at extremely high speeds in the more modern mills. The oil selected must have a viscosity permitting loads to be carried all the way from threading speed to maximum operating speed, and particularly in 5-stand tandem cold reduction mills, it has been found desirable to use two different viscosities of oil. The heavier of the two is used in stands 1 and 2, and the lighter, usually about one-half the viscosity, is used in the last three stands. In order to accomplish this, it is necessary to have two separate lubrication systems. Better starting conditions and cooler operation of the bearings at high speed result from this type of installation.

Table I mentions mill scale as a contaminent in systems serving bearings for temper mills. We question whether mill scale is a problem, as far as bearings and oil used in lubrication systems is concerned, in these mills.

On the subject of water and mill scale contamination of lubricating oil in hot strip mill bearing systems, the paper states that the viscosity of oil used ranges from 2000-2500 SSU at 100 F. In many cases, lighter oils are used even down to 1200 SSU at 100 F.

It is very necessary to provide good seals for the bearings. In one type of modern oil-lubricated roll neck bearing, three seals are provided against ingress of water, and oil is retained successfully in the bearing by a rotating dam or flinger. In addition, water deflectors

are recommended for bottom bearings to minimize the amount of water that actually impinges on the outer water seal. Of late, an end face type water and oil seal is being tried in the field and shows some success to date.

The authors make the point that receiving tank should be of ample size in order to have enough resting time for the oil to permit it to drop contaminants, including water. This is most important. It is just as necessary to maintain proper oil level in the operating tank and at all times it should not be less than three-fourths full. If the level is allowed to go down below that point, the resting time suffers.

What is the proper receiving tank size? As a general rule, we recommend that the receiving tank size in gallons should be 50 times the pump capacity in gpm. Thus with a full receiving tank, the resting time of the oil is 50 minutes and with the tank three-fourths full, the resting time is 37½ minutes.

Now with reference to Figures 2 and 3, which show respectively receiving tank without baffles and one with baffles, we question the necessity and desirability of baffles. Years ago single receiving tanks were used and they were equipped with elaborate baffling. With the advent of dual tank systems and the increase in size of receiving tanks in comparison with the capacity of pumps, it was found that successful operation was attained without the complication of baffling. This simplified cleaning of tanks and permitted one steam heating coil per tank to be used instead of two or three. The oil in the bottom of the tank is usually not cool, because most of the time heating coils are in use and the temperature of the oil in the tank, although it is hotter toward the top, is not very much different from that of the incoming oil. For that reason, we do not believe that the path of the oil is correctly shown on Figure 2. We do not see how vertical baffles reduce the rate of flow of the oil through the tank. The rate of flow is constant for the mill at a given speed. While baffling may increase the length of the flow pattern, it will also increase the speed of flow.

Regarding suggestions for holding receiving tank oil temperature in the operating tank at 150 F, we do not believe that operating companies would want to invest in over-size heat exchangers nor to provide the water for them. If it is desired to recondition oil in the operating tank, it can be done by by-pass centrifuging with a centrifuge equipped with electric heaters, so that only the oil going through the centrifuge will be heated to the higher temperature. Neither do we believe that it would be good for the oil to carry it at the higher temperature.

If adequate centrifuge equipment is available in the oil cellar and if operated systematically, we do not believe emulsion breakers will be found necessary providing, of course, that bearing seals are properly maintained.

Many systems are operating with water content held quite low without the use of emulsion breakers.

In the part of the paper which discusses water and mill scale contamination of cold strip mill lubrication systems, we do not believe that it is ever necessary to heat oil in a resting tank above the boiling point of water. It would certainly not be good for the oil and, if the condition requiring it occurs, it is an indication that proper care of the oil has not been taken.

The paper states that the range of viscosity used in cold strip mills is from 800 to 2500 SSU. Very fast mills are operating at present on viscosity as low as 600 SSU and some very slow mills are using oil up to 5000 SSU at 100 F.

In conclusion, we agree heartily that proper maintenance of seals is most necessary and when they are properly maintained, dividends are paid in longer life of oil and reduced losses.

M. S. Clark: Mr. Cichelli asked what the petroleum industry was doing in regard to improving the water separating qualities of circulating oils. I cannot speak for the whole industry, but I do know, as far as our company is concerned, we are attacking this problem from two angles; first, improving the products in use now and second, experimenting with various crudes, since we know that some crudes are better than others. Progress is being made and we expect to have improved products in the not too distant future.

E. E. Perso: Mr. Cichelli asked about our recommendation for protection of tanks against corrosion in circulating systems.

We frankly agree that tanks in oil circulating systems should be coated to protect them against rusting.

Mr. Cichelli also questioned the advisability of installing baffles in circulating tanks, stating that these increased the speed of oil circulation in the tank. The function of the baffle is to overcome stratification of the oil in the tank during operation. We consider the baffle as a mixing device so that all the oil in the tank will be circulated and not flow directly from the bearing return to the pump suction.

Western mills are getting larger and today they have some good sized units. Some ideas and procedures developed may be of interest here. For example, palm oil is being separated from the circulating oil in the system of a five-stand strip mill. This mill has two 14,000-gal tanks which are rotated every ten days. Oil is treated as follows:

1. Spray 1000 to 1500 gallons of water into tank.
2. Heat by steam coils to 200 F.
3. Let stand at this temperature for 24 hours, with *no agitation.*
4. Turn off heat and let cool for 24 hours to approximately 100 F.
5. Drain off water and centrifuge oil to remove remaining water.
6. This treatment removes most of the palm oil from the circulating oil.

A very practical and most effective method of lubricating spindle couplings is used by a large Western mill where a 750 SSU at 100 F lead naphthenate extreme pressure gear lubricant is sprayed one minute every half hour on the couplings.

An air operated barrel pump supplies lubricant to a spray nozzle mounted as close as possible to the coupling. Automatic controls start and stop the pump and admit compressed air for atomization. Air continues to blow through the spray nozzle for a half minute after the pump has stopped. This clears the nozzle and prevents it from clogging. Increased tonnage on the mills is claimed for this method of spindle coupling lubrication due to no "down time" required for lubrication. Replacement of bronze slippers has been reduced 50 per cent or more.

By CHARLES D. SPADONE, Vice President, Spadone-Alfa Corp., New York, N. Y.

Oilless Bearings—Their Place in Industry

. . . . oilless bearings find applications for conditions requiring cleanliness, high temperatures, or where maintenance is difficult . . . .

▲ OILLESS bearings containing a solid lubricant in the bearing wall were first brought to the attention of industry some eighty years ago with the development of a metallic plug type bearing, known as metaline.

This type of oilless bearing was first visualized by Dr. Stuart Gwynn, engineer, chemist and inventor who understood the great need in industry for a bearing that would operate without maintenance under exacting conditions of cleanliness, high temperature and heavy loads. After a long period of experimentation, he succeeded in developing a formula for a lubricant having expansion properties and consisting of minerals finer than the surface particles of any cast metal. These, when subjected to rubbing, filled the microscopic pores of the shaft and bearing metal and coated the moving parts with a highly polished film.

The next problem was to find a practical way of applying the lubricant to the bearing. After exhaustive experimentation, it was felt that the premolded "plug" form gave better results than could be obtained by applying lubricant to grooves or spirals cut or cast in the bushing. It was noted that if any part of the groove broke down, the tendency was toward continued disintegration of the bearing surface. The plug type bearing was therefore adopted and the plugs formed by subjecting the ingredients of the formula to extreme pressures ranging upward from one hundred tons psi.

The plugs were then inserted into specially drilled holes in the bearing wall, each plug serving as a lubricant reservoir.

The bearings proved successful under actual operating conditions and constant study and application of the advances made in metallurgy have resulted in an ever widening use and acceptance of metallic plug type bearings.

Although comparatively little has been written on the subject, it would be difficult to find an industry today that does not make effective use of oilless bearings in some application. A combination of careful research and practical experience has kept them abreast of changing conditions and engineers find them a solution to many difficult bearing problems. The tremendous increase in production during the last decade has demanded higher operating efficiency and oilless bearings have continued to meet the greater temperature, load and speed requirements. The term "oilless" should not be confused with "self lubricating" for as the name implies, oil or grease is not contained in the bearing itself nor is it necessary to add these or other lubricants. Perhaps an easier way of distinguishing between the two is to remember that oilless bearings are lubricated by means of a solid or dry lubricant whereas self lubricating bearings rely on fluid or viscous lubricant. This distinction makes it readily apparent that oilless bearings will normally function in higher temperatures than the self lubricating types which tend to exhaust their lubricant under heat conditions.

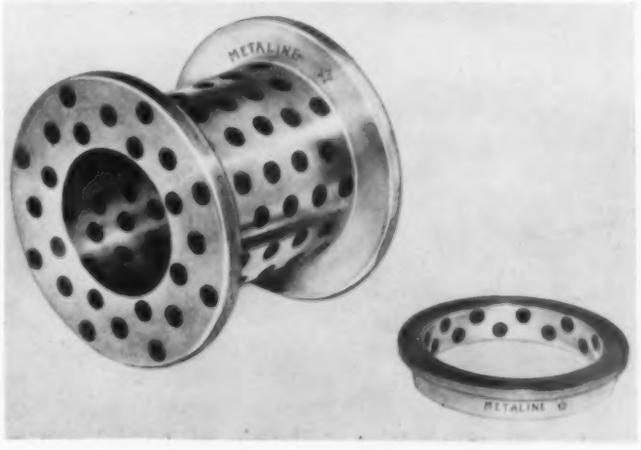
In this study we are essentially concerned with oilless bearings having a dry metallic lubricant, but it is also important to consider other main types in this bearing classification.

For the sake of discussion, these are broken down into four groups.

1. Composition metal bearings containing lubricant in the mixture.
2. Composition plastic and rubber bearings containing lubricant in the mixture.
3. Carbon graphite bearings.
4. Solid metal bearings drilled or grooved to hold the lubricant.

Composition metal bearings usually consist of bronze or iron powders mixed with graphite. The mixture is then compressed into form under high unit pressure, sintered for strength and hardness, and may or may not be subject to final machining depending on method of manufacture and required tolerances. The composition

Figure 1 — The appearance of the bearing has given rise to the term "the bearings with the measles."



oilless bearings are similar to self lubricating oil impregnated bearings in porosity, but as graphite is inert, they tend to be somewhat brittle. However, under moderate conditions of load speed and temperature, they give efficient service.

Bearings of this type are also made in several other ways. One method is to machine a solid graphite bar to dimensions after which it is immersed in molten bronze or other alloy. The metalized graphite is then placed under pressure for final form and finish. Another process is to press a mixture of graphite and metal powders into block or core form. The piece is then machined to final dimension. Suitable for light duty at higher speeds, recommended loads run about 50 psi of projected bearing area and temperatures approximately 200 to 300 F.

Composition plastic bearings consist of plastic compounds often mixed with a percentage of graphite and are effective when used under abrasive conditions. Having less wear resistance than metal, the abrasive wears the bearing rather than the shaft. These bearings are also known as phenolic resin or laminated, and most efficient operation is obtained when they are used in solution or employing water as a lubricant. This is particularly true of rubber bearings.

Plastic bearings have low heat conductivity and temperatures should be kept within 200 F. The type most widely used in the steel industry are roll neck bearings, and they are most efficient when water is used as a lubricant. However, for general use, if loads and speeds are moderate the impregnated graphite lubricant is usually sufficient.

Carbon graphite bearings are a mixture of carbon and graphite powders compressed to shape and finished to final dimensions. Certain sizes accept a minimum tolerance of 0.010, and where smoothness is required polishing may be employed. Porosity varies with the grade of carbon graphite used, and some will not absorb any fluid while others may absorb up to 20 per cent by volume. The expansion and contraction of this material is about the same as metal which is therefore frequently used as a backing to impart strength for heavy load or high temperature application. These bearings can be run dry or lubricated with light fluids as desired, and 100 psi at 300 fpm and 250 F is representative of the operating range. Coefficient of friction ranges from 0.04 to 0.25 depending on the grade used.

Solid metal bearings drilled or grooved to hold the lubricant comprise the fourth group which consists of two main types: bearings lubricated with graphite paste wiped under pressure into recesses, holes or grooves and then heat treated to form a compact mass; and bearings lubricated with premolded metallic plugs inserted in the bearing wall.

The metallic plug type bearings are similar in appearance to those lubricated by graphite only, but they have a wider range of application and provide longer service under heavier load and higher temperature conditions. Under normal use, the metallic lubricant will last the life of the bearing.

These bearings are made of cast bronze, cast iron or other metals depending on requirements. They are usually not a stock item but made to order, and can be furnished in an unlimited variety of sizes and shapes. They are therefore of particular interest to the machine designer and maintenance engineer.

Before going further in our consideration of oilless bearings in the finished form, it may be helpful to give some thought to various dry or solid lubricants that bear out the theory of solid lubrication. It is commonly accepted that the two main types of friction created in mechanical actions are either solid or fluid, and the effect of solid lubrication on solid friction has been clearly described by T. C. Thomsen, in his book "The Practice of Lubrication." In essence he states: When solid lubricants are introduced between unlubricated surfaces they act as smoothing agents filling pores and imperfections in the metal surfaces and coat the surfaces with a thin layer of solid lubrication. Solid lubricants have little cohesion and therefore when abrasion takes

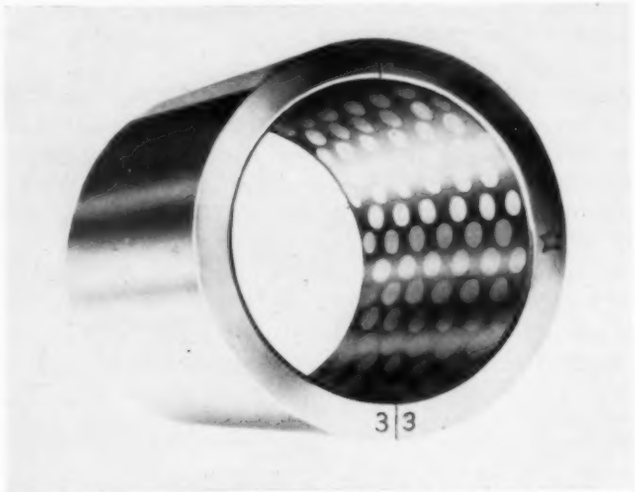


Figure 2 — Bearings may be furnished as two semi-circular segments.

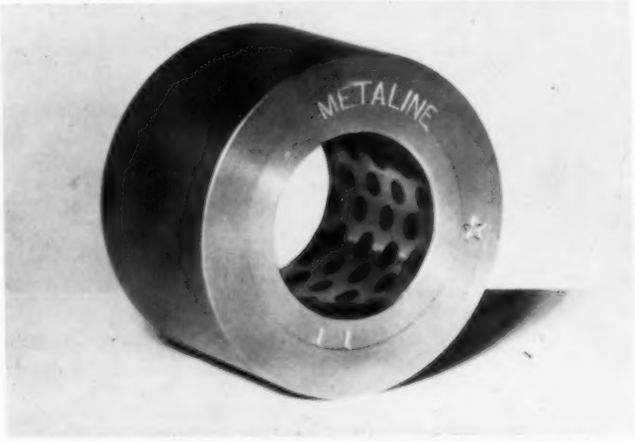
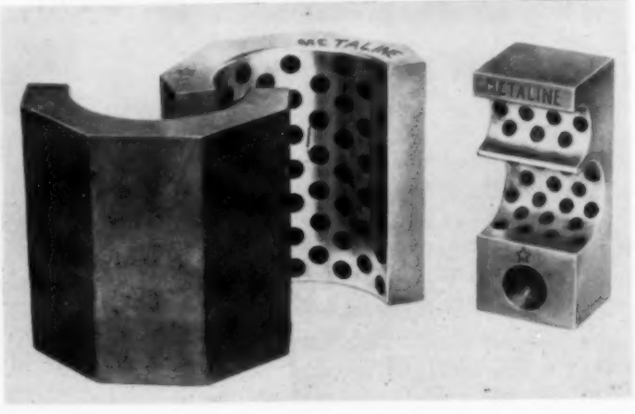


Figure 3 — Bearings may be furnished as an insert.

Figure 4 — Bearings are furnished in many shapes.



place, it is between particles of the solid lubricant rather than the original surfaces. By use of a solid lubricant, the solid friction of the original surfaces is actually replaced by a lesser solid friction between the lubricants. Thus when solid lubricants are used, abrasion and cutting of the original metal surfaces is less likely to occur. Thomsen adds, that addition of a solid lubricant to a fluid lubricant in a perfectly lubricated installation did not interfere with performance. Moreover, it was found that although friction increased right after adding the solid lubricant, as soon as it had time to adhere to the surfaces friction was reduced.

One of the many virtues of solid lubricants lies in their effect on the rubbing surfaces at the moment of starting. Because the lubricant coats or films the original surfaces and as this film will stand up under stationary load and resists squeezing out, there is a resultant reduction in the static coefficient of friction at the moment of starting. It is generally agreed that use of dissimilar metals for the rubbing surfaces is desirable from both a friction and seizure standpoint. Cast iron and hardened steels may be exceptions to this rule, but even they should not be used for both members when bearing pressures are high. Solid lubricants in the pure state having above average film forming characteristics are graphite and molybdenum disulphide. Both have laminar structures, perform well under heavy load and maintain low coefficients of friction in high temperatures. Molybdenum disulphide, MoS_2, is the most recent of the dry lubricant group and although first results were disappointing most failures were traced to improper refinement. Now produced in a highly pure form, MoS_2 has proved efficient and in many cases superior to graphite. It tends toward a lower friction value than graphite, particularly at higher sliding velocities, has excellent film producing properties and has above standard resistance to pushing or squeezing out.

Like other dry lubricants, MoS_2 is more or less effective depending on its bond to the moving surfaces. The life of an effective film is dependent on its resistance to being plowed up or pushed out. This resistance is in turn dependent on the toughness of the film and its tenacity for one or both of the sliding surfaces. Thus users are continually striving to find ways and means of increasing this tenacity or bond characteristic.

Molybdenum disulphide is still too new to permit many set or far reaching conclusions, and there is some difference of opinion on its effectiveness under actual operating conditions. Nevertheless, it appears to be a most promising member of the dry lubricant family and with the development of better mixtures and means of application it is hoped that further improvements in the operation of oilless bearings can be effected.

Boyd and Robertson, in their paper "Friction Properties of Various Lubricants at High Pressures" show molybdenum disulphide, graphite, and tungsten disulphide to have the most stable and lowest average coefficients of friction of various lubricants tested. Two of these lubricants had an average coefficient of friction of 0.032 and graphite had 0.036. In comparison, machine oil, which was one of many other lubricants tested, had an average rating of 0.099. These figures serve to illustrate the very definite place and value of oilless lubricants in the lubrication field.

Obvious advantages of dry or solid lubricants include:

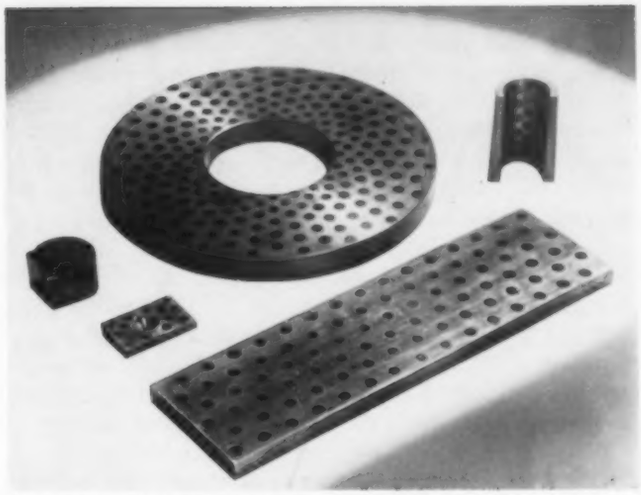


Figure 5 — Extensive laboratory work is being carried out on the application of oilless bearings.

1. Reduction of solid friction.
2. They fill pores and irregularities in metals and provide a highly polished surface film capable of withstanding heavy loads and resistant to scoring or abrasive action.
3. They do not require maintenance and are ideal for inaccessible locations.
4. They greatly reduce consumption of lubricant.
5. They substantially reduce maintenance cost.
6. They assure dependable lubrication under high temperatures.
7. They exhibit a high degree of resistance to squeezing out and maintain maximum lubrication under static load. Coefficient of friction at time of starting is therefore relatively low.
8. They are clean and prevent fire from oil or grease drippings.

There are of course other dry lubricants such as silicones, soapstone, silver sulphate, magnesium stearates etc., but we do not attempt to cover them all as their use is not prevalent in oilless bearing lubricants.

In recent years it has been recognized that certain properties should be considered in determining the advantages or limitations of a bearing for a particular application. These properties were originally set forth as pertaining only to the metal or alloy, but whether intended or not, they have proved helpful in describing various properties of oilless bearings. Bearings intended for oilless operation should have better than average rating in most of these classifications.

Conformability — This is the ability of the bearing to conform to surface irregularities of the shaft thus affording more uniform distribution of the load. Plasticity is inherent in this characteristic and if, for instance, we are to compare the premolded plug type bearing to a babbitt bearing we would have to assign it a low degree of conformability. On the other hand, when compared to a plain sleeve bearing its rating would be high. The premolded plugs composed of metallic oxides and other soft ingredients expand under frictional or induced heat at a greater rate than the metal in the bearing wall. As the plugs expand, a film is quickly built up on the moving surfaces. This expansion and resultant film thickness varies with the pressure points within the clearance and tends to evenly distribute the load.

Non-scoring characteristics — Possibility of scoring is usually most prevalent during the starting up period or when the range of critical operation has been reached. Oilless bearings, particularly those in the metallic lubricant group, rate highly in this respect. The polished hard protective film protects the journal under both static and running load. When run within recommended operating range, scoring should never be a problem.

Compressive strength — This is the ability of the metal bearing wall to withstand load and shock without distortion or breaking. Taking the solid bronze plug or grooved bearing as an example, we find the bronze most generally used for normal application has a compressive rating of 14,000 to 16,000 psi. In terms of load, capacities range from 1000 psi projected bearing area up to 4000 psi for an aluminum bronze. Depending on requirements, materials other than bronze may be used, but in any event, this type bearing is considered to have a most satisfactory compressive rating. Flexibility in choosing the most suitable metal for the application is also an advantage.

Fatigue resistance of bronze, cast iron and similar metals is high enough to cause little concern, but it is important when considering white metal, aluminum or copper alloys. However, it is seldom necessary to emphasize this factor when determining the suitability of solid metal oilless bearings for an installation.

Embeddability — The ability of a bearing to permit dirt or foreign matter to embed in its surface thereby minimizing abrasive action and scoring of the shaft. Oilless bearings rank high in this respect as any grit is quickly driven into the holes containing the softer lubricant. Pressure tends to hold the dirt particles in the recess and away from the contact wearing surfaces. Naturally, if grit conditions are excessive, the life of the bearing will be shortened, for the grit will displace and force out an equivalent amount of lubricant. However, in such instances it is usually practicable and less expensive to sacrifice the bearing rather than risk damage to the shaft or equipment.

Corrosion resistance is self explanatory and oilless bearings are often chosen on the basis of this property alone. Being oilless, the problem of oil oxidation at high temperatures and resultant organic acid is automatically avoided. In addition these bearings are widely used in underwater installations and will serve in surroundings where chemicals in the atmosphere would affect other lubricants.

Clearances — The subject of clearances is most important in considering the success or failure of any bearing application. The clearance of plain or sleeve type bearings is that difference in size between the diameter of the shaft and the inside diameter of the bearing. This space or clearance accommodates the metallic film or lubricant which prevents metal to metal contact of the moving surfaces. Bearing performance, life and machine operation are all greatly affected by clearances.

It is impossible to set hard and fast rules for all applications and clearance data is usually based on a study of the factors involved in a given operation.

Standard clearances as set forth by the manufacturer can of course be relied upon under normal conditions, but when seeking information it should be remembered that load, speed, temperature, shaft size and type of bearing required are highly important factors when determining proper clearance.

Premolded metallic plug bearings allow for generous clearance as there must be room for the plugs to expand and build up a protective coating on the shaft and bearing wall. Clearances vary with the size of the bearing and operating conditions. They may range from 0.003 for smaller bearings at normal temperature up to 0.042 for larger bearings at 800 F. When compared to oil lubricated bearings this may seem excessive, but when the film building properties and expansion of the lubricant are taken into consideration, it can be seen that the final operating result is a normal running fit between journal and bearing.

Proper installation is another factor directly related to both clearance and operation efficiency. Improper alignment or fit are obvious trouble makers, but often overlooked are the thermal expansion properties of the metals employed. For instance, the temperature coefficient of bronze is higher than that of cast iron and steel. Thus if the bronze bearing is housed or backed by these metals, the expansion can only be inward with resultant loss of clearance. Uneven wear, distortion or seizure may result, and the bearing blamed for failure that was actually the fault of improper installation. Trouble of this sort can usually be avoided by asking the manufacturer for recommendations.

Sizes and shapes — Machined in a countless variety of sizes and shapes, oilless bearings have few limitations and are constantly referred to and used by designers, builders of machinery and maintenance engineers. The most common shapes are plain and flanged sleeve types furnished both split or solid as required.

Two piece plain bushings are made in halves so that when fitted together a perfect cylinder or bearing results. Bearings of this type are made by soldering sand cast halves together and machining to dimensions. They are then separated and the bore surfaces drilled or grooved to accommodate the lubricant. Two piece bearings are used when design or location of the bearing does not permit use of the one piece type.

Half bearings — When considering the use of half bearings, it is important to determine whether matched halves will meet requirements. As previously explained, two piece bearings are normally made in matched pairs machined in one operation to form a perfect cylinder. This method of manufacture is less costly than making one half separately and performance of the bearing is in no way impaired. On the other hand, if the halves are made individually due to variances in normal tolerances, an exact match is not necessarily assured. Naturally there are times when individual halves having a true centerline are essential, and such specifications should be so indicated. However, whenever possible the matched pair method of making halves should be specified.

One piece bearings are machined from cylindrical castings and then drilled or grooved for the lubricant which is later smoothed down to the bearing dimensions. For optimum results, they should be installed press fit in the housing so that all lubricant will be forced in the direction of the shaft. One piece plug type bearings are lubricated on both outside and inside surfaces and are readily adaptable in those instances where a floating bearing is required.

Flanged bearings — The principal reason for a flange in sleeve bearings is when end thrust is a factor. In such instances the flange face or faces should be lubricated, but if the flange is to serve merely as an anchor or divider, lubrication is not necessary. Flange bearings are usually sand cast, and within the limits of good design the flange thickness can be made to suit requirements.

Thrust washers, discs, rings, segments, yokes, slide and wear plates and square bushings are illustrative of the many sizes and shapes practical for oilless lubrication.

It can be safely said that the theory of sound design as it may apply to a particular application is the only limiting factor in furnishing a bearing to specific size or shape. The usefulness and dependability of oilless bearings are now generally accepted and many new sizes and shapes have been developed which carry only slight resemblance to conventional types. Oilless bearings offer another important advantage as parts finished outside by special process can be forwarded to the bearing manufacturer for introduction of the lubricating medium.

In this paper considerable mention has been made of metallic plug bearings or metallic plug lubricants and this has undoubtedly raised the question as to just what this substance actually is. Webster's Dictionary defines it as "Metaline" a substance resembling a soft dark colored metal used in the form of plugs inserted into machine bearings for obviating friction. Actually metaline plugs are made of a mixture of metallic oxides, waxes, organic salts and other materials. For obvious reasons, mixture formula and complete list of ingredients are not publicized, but it can be stated that the success and effectiveness of this lubricant is wholly dependent on the proportion and skillful mixture of each substance in the compound. Each particle has its own quality of lubrication, and through proper combination each complements and strengthens the other. This combined solid offers a greater range of application than any other dry lubricant used in the pure state. First developed as Metaline and widely known today under that name, this lubricant effectively resists many acids, solvents, chemicals and water, heat and cold conditions.

PRACTICAL ENGINEERING DATA OF GENERAL INTEREST

Load capacities — A conservative load rating per square inch of projected bearing area is 1000 psi. Loads of 4000 psi projected bearing area are also permissible depending on metal alloy used. As a general rule bronze oilless bearings will withstand the same pressures that comparable oil lubricated bronze bearings will stand.

Temperature — These bearings are recommended for temperatures up to 750 F but this is commonly exceeded. For instance, there are known applications where bearings have given 24-hr service at 800 F over a long period of years. These oilless bearings are also widely used in oven cars which are often subject to temperatures over 1000 F and their efficiency and service are known to be satisfactory. However, caution and common sense should be exercised when operating recommendations are exceeded. A good rule to follow is that when one of the factors of load, speed or temperature is excessive, the others should be reasonable. Due to the many variables in bearing operation, theory will take us just so far, and in the final analysis the most reliable answer is found through test and observance of the bearing performance under actual conditions.

Speeds — Recommended speeds for oilless bearings are given in surface feet per minute and over 500 fpm is considered critical. As surface speed is affected by shaft size, there is of course considerable variance in terms of rpm.

Wall thickness — Plugged or grooved bearings should have a wall thickness heavy enough to permit proper introduction of the lubricant. Wall dimensions range upward from 3/16 in. for smaller bearings to 7/16 in. for larger bearings, and although these represent normal recommendations they are subject to change if special conditions warrant.

Bearing length — Optimum length should be 1½ times the inside diameter. However, in actual practice this rule is often deviated from, and in the case of sheave bearings most are made with length about equal to the diameter. When necessary to design a bearing for heavy loads, we suggest that whenever possible the length be increased rather than the diameter.

Coefficient of friction will vary with the application and because of the many variable conditions specific information is not always available. It is unfortunate, but because frictional tests are conducted under controlled conditions the results are usually given in indicative rather than conclusive terms. The frictional coefficient of metallic lubricated bearings is similar to that of graphite and ranges from 0.04 under heavy load to 0.17 under light load.

These specifications are determined from practical experience and allow for other variable factors, difficult to predict, but nonetheless affecting bearing operation. Machine vibration, shaft distortion, improper installation and excessive abrasion cannot be anticipated and although manufacturer's recommendations include some margin of safety if the application is critical, actual trial of the bearing is the only dependable way of knowing what performance could be expected.

This is best illustrated by a test made to determine maximum load capacity of a two piece metallic plug bearing 2-in. inside diameter × 2¾-in. outside diameter × 1½ in long.

Load in psi on projected bearing area	Rpm	Results
1867	34	Bearing slightly warm.
4000	34	Bearing warmer, could be held in hand.
5000	36	Bearing too hot to hold, no damage, running free.
8000	36	Bearing hot, running free.
8000	38	Bearing smoking, not injured, running free.

Thus through actual test, in this instance, performance exceeded the normal recommendation.

Capacities of the metallic plug type bearing are further indicated by mention of a few of their many applications in the iron and steel industry.

Cars — Oven, furnace, cinder, etc.
Crop pushers — Slabbing mills.
Shear depressing table — Blooming mill.
Strippers — Piercing press.
Trolley bearings — Electrical cranes.
Oven machinery bearings.
Soaking pit headers.
Back shear table — Merchant mill.
Twist rollers — Hot bar mill.
Hot strip coilers.
Conveyor rolls.
Hot saw presses.
Gang tables.
Soaking pit cranes.
Mill reel guides.
Sheet levelers.

Manufacturers are continually striving to meet new conditions and it is recognized there is still room for improvement in the present bearings. Extensive research and laboratory tests are now being carried on and it is hoped the results of this work will open the door to broader use and application of oilless bearings.

What the future holds is impossible to predict, but the place of oilless bearings in meeting the needs of industry is well established and although they are not represented as a "cure-all" when cleanliness is important, maintenance difficult, high temperatures must be met or special design essential, industry looks to the oilless bearing as a probable solution.

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DISCUSSION

PRESENTED BY

D. E. WHITEHEAD, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

CHARLES D. SPADONE, Vice President, Spadone-Alfa Corp., New York, N. Y.

WALTER LAUTERBACK, Partner, Carl Karthauser and Co., Pittsburgh, Pa.

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

D. E. Whitehead: In presenting his interesting paper, Mr. Spadone hesitated to refer to the popular sobriquet allocated his bearing by the men in the mills, as, the bearing with the measles. I have seen this bearing used in quite a wide variety of applications. As an example of an extreme, such bearings were used as vertical roll neck bearings on one of the larger and most modern slabbing mills in the industry. They fulfilled several objectives then. Under war production pressure, mill down-time was at a premium and was permitted, only to avert acute operating or maintenance situations. Requiring no intrinsic lubrication, the spaghetti-like grease hose connections under the mill were eliminated and downtime from disconnected, broken or fire (hot cobble) damage averted. A sudden bearing failure as a result of a lubrication stoppage could not occur. Service life compared favorably with straight brass bearings and no lubricating grease cost. The bearings performed splendidly in other roll neck applications, soaking pit cover bearings, hot transfer cars, ladle and cinder pot cars, heat treat furnace car bottoms and as journal bearings for railroad operating hot slab and hot metal cars (short runs).

The manufacturer has always taken a very conservative approach to problems where an application may be questionable, being particularly cautious where sticking or incipient seizing may result from bearing inactivity for periods of hours or weeks in the presence of high temperatures. In all aforementioned applications where such a condition existed, no sticking problems of any consequence were encountered.

I wonder at this time and would like to ask the author whether the application of metaline inserts has been extended to include the field of phenolic resin bearings, since the conditions of ample water lubrication and a requirement of minimum additional lubrication are indicated, the metaline inclusion in phenolic resin bearings should be practical.

Charles D. Spadone: The two questions as I understand them, are: "What are our thoughts regarding the effectiveness of metaline bearings on oven cars? Have we changed them in the last seven years?" No, we have not changed them. We find they do a good job on oven cars, particularly if the cars are kept working. When the cars are idle for long periods, there is sometimes a tendency for the bearings to stick under the static load. However, taking the overall they do a good job.

D. E. Whitehead: Have metaline plug inserts been tried in phenolic bearings?

Charles D. Spadone: No, as yet we have no final answers on this. I can say we have been doing some thinking on the subject and the feasibility is under consideration at this time. However, it appears that efficiency of a phenolic resin bearing having metaline inserts would be limited to certain applications. Under conditions of heavy load or shock, the resiliency of the plastic might tend to dislodge the plugs, thereby de-

stroying the effectiveness of the bearings. We hope to have a more definite answer on this within a year or so.

Walter Lauterback: I would like to say in reference to Mr. Whitehead's question on use of metallic plugs in phenolic bearings, Jones and Laughlin did try that setup on the South Side, and we never did get a conclusive report on that application.

A. E. Cichelli: In designing equipment, the designer is often confronted with the problem of how to lubricate the bearing in an application that is hard to get to, is hot, and so on. He invariably resorts to the type of bearing you discussed this morning. Unfortunately, I believe those bearings are often subjected to conditions that the designer never even suspected, and maybe if he knew what he was up against, he would not recommend this type in the first place.

My point is this: Oftentimes, as much as we hate to do it, with this type of bearing, we find it advisable to give it some form of a fluid lubrication, for one reason, if for no other, and that is to keep the bearing flushed. The solid lubricant that is in the original bearing certainly performs a function, especially when one has reversing conditions also as in the case of failure of fluid lubrication. In this case, the solid lubricant plays a secondary, but necessary role. The fact is that we resort to fluid lubrication first, and then solid lubrication if the fluid lubrication fails.

Charles D. Spadone: Your comments raise an interesting point and there is no denying that the addition of a fluid lubricant to bearings having a solid lubricant will increase efficiency in certain applications. However, it must be understood that although effective, this practice defeats the purpose of using an oilless bearing and will eventually cause disintegration of the plug lubricant thereby shortening the life of the bearing.

WHEELING STEEL'S CONTINUOUS GALVANIZING LINE

By
F. L. REED
Industry Engineer
Westinghouse Electric Corporation

▲ WHEELING Steel has recently put into operation a new continuous galvanizing line which operates at speeds up to 300 fpm in the galvanizing or process section.

The line is electrically divided into four sections: entry, process, delivery, and classifying. The entry section feeds a storage loop at a speed above that of the process section until the loop is full, and then is automatically slowed down to process section speed by photo-electric switches placed in the storage pit. The entry section consists of a welder for welding coils together and a side trimmer for trimming the edges.

The process section runs at a constant speed and consists of entry drag bridle, cleaning tanks, galvanizing tank, dryer and process bridle. The entry drag bridle regulates the tension in the process section. The regulating is done by a tension regulating rotating regulator. The speed of this section is controlled from a speed control rotating regulator with the process bridle acting as the master for the line.

The process section feeds the strip into a loop which is automatically controlled by photo-electric switches which governs the rate the loop is removed by controlling the speed of the delivery section. The delivery section consists of a delivery drag bridle and a tension reel. The tension reel has a tension regulating rotating regulator for controlling the reel operation during buildup.

The galvanized strip may be either coiled or cut in sheets and piled on a conveyor. When the strip is cut to length, the coiler is by-passed and the strip is fed through a flying shear, onto conveyors and on through a leveller and sheet piler.

A pin hole detector and thickness gage is used to detect faulty strip. This equipment is located ahead of the cleaning section and has a memory device which marks the strip as it leaves the processing section. The bad sheets can thus be rejected before they get to the prime piler.

This type of electrically controlled continuous line is a great improvement over the old method of hand dipping, resulting in a much more uniform product.

HELPER DRIVES
Help Steel Processing Lines

By E. E. VONADA, Applied Engineering Dept., The Reliance Electric and Engineering Co., Cleveland, Ohio

. . . . as processing lines become more complex and attain higher speeds, the role of the helper roll drive will become of paramount importance . . . .

▲ OVER the years there has been an ever-increasing tendency toward combining a multiplicity of production processes into a continuous arrangement, to obtain continuity of operation. Modern electrolytic tinning lines, cleaning lines, and continuous annealing lines are good examples of this in the steel industry.

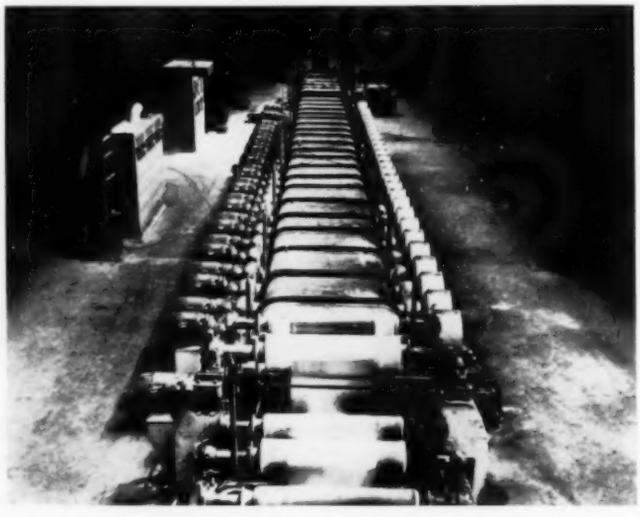
In order to conserve valuable floor space, processing units have been designed so that necessary exposure time of the strip steel to the process must be obtained by passing the strip vertically through the units. This method, of course, necessitates the use of many guide rolls around which the strip must pass. The increased bearing friction losses and inertia of these guide rolls, combined with the losses incurred by bending the strip 180 degrees around them, results in excessive strip tension at the main strip propulsion drive unit.

The necessity for helper drives became apparent in the steel industry twelve years ago when the first electrolytic tinning lines were put into operation. It has only been within the last five years that strip propulsion helper drive systems were recognized as an important item. Various mechanical and electrical propulsion drive arrangements have been employed to eliminate the operational problems with varying degrees of success. In the early part of this latter period a steel plant in the Pittsburgh, Pa. area initiated a modification program to increase operating speed on one of their tinning lines. Operating experience had provided sufficient evidence to the steel mill engineering and production groups that some system must be employed to assist in propelling the strip through the plating section of the line. This was dictated because of the increased number of passes, and to provide the increased horsepower required for an increase in line speed. We proposed individual helper drive motors for each conductor roll, and were chosen as the supplier for this proposed equipment. Two important predictions involving motor size and quantity were made and borne out on this individual helper drive motor installation. It will be necessary to briefly outline the complete application to better understand the significance of these two factors.

Limited operating speed range and customer preference dictated the application of a-c helper drive motors. These motors were individually direct-coupled to each conductor roll. An adjustable-frequency alternator was employed to provide change in speed over the limited operating range. The necessary high torque for starting and accelerating was produced by alternator field-forcing, pre-set non-lineality of frequency, special high-torque rotors and highly saturated stators in the motors themselves. It was recognized that the starting and accelerating characteristics of the helper system were of paramount importance to the application, and the measures outlined above adequately provided for these requirements. The high-torque, high-slip characteristic of the motors automatically provided for the second basic necessity for helper drives — that they have the ability to share load. This means that the motors are always trying to draw the strip faster than it is actually moving, or in other words, the motors cause each succeeding roll to tug on the strip. The degree of tugging was easily adjusted for desired operating condition by modifying either alternator frequency, alternator field strength, or a combination of the two.

In the early stages of the negotiation there was con-

Figure 1 — This battery of gear motors is used as helper drives on a tin line which runs at speeds up to 1500 fpm.



siderable debate over the problem of arrangement or distribution of the helper power in the line. Economics dictated placing a few high horsepower units along the line. Good engineering called for many smaller units. The use of many small motors represented higher first costs for the electrical equipment, roll shaft extensions, couplings, mounting pads, motor protective devices, and a possibility of increase in maintenance costs. Fortunately, agreement was reached on two basic premises. These were that torque applied to a roll should not greatly exceed that necessary for accelerating and decelerating the roll or rolls, the bending losses of the strip around the roll, and friction and pumping losses if a solution exists; and that strip tension build-up is compounded from the entry to the delivery end of the processing section.

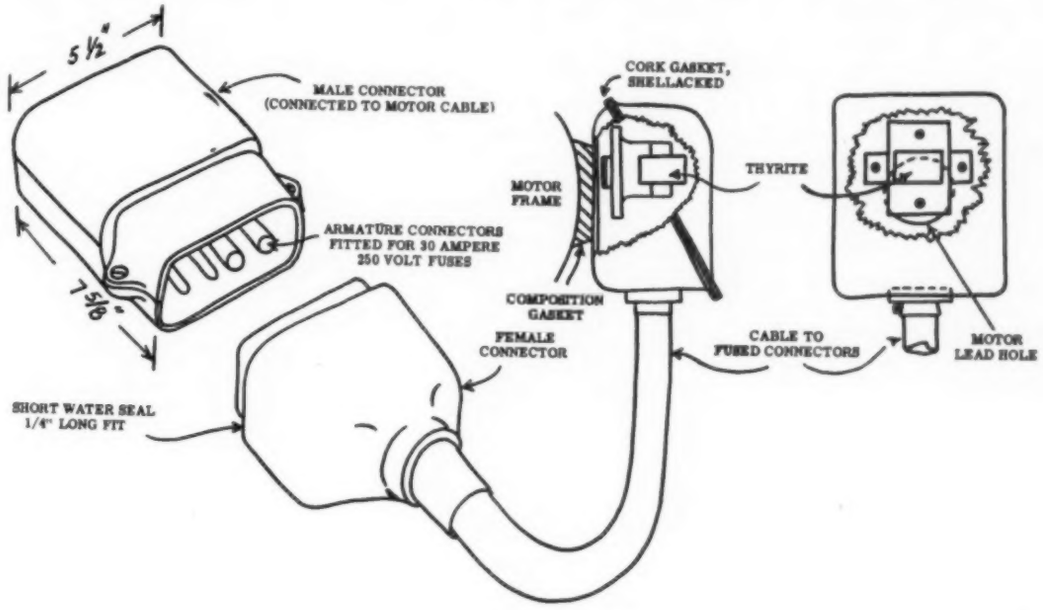


Figure 2 — Diagram shows a method for protecting and disconnecting helper drive motors.

It was mutually agreed that attempts to apply strip propulsion help in large power blocks would probably result in greatly increased bearing friction losses as a result of high strip tension at the rolls immediately preceding the point of power input. Economics gave way to good engineering practice, and twenty-four 2-hp, a-c motors were installed.

Wisdom of the decision to apply a large number of small motors, and proof of the initial premises were borne out when the line was started up. Initially, it was impossible to approach maximum rated speed. Even at reduced speeds, considerable strip breakage occurred at the main pulling bridle. As is natural with anything new, a decision was quickly reached that if the helper drive motors were doing anything at all, they were actually holding back, rather than trying to propel the strip through the line. Four of the 2-hp motors were replaced with 10-hp, d-c motors and a great deal of potential was put behind them. The result was an increase in pulling bridle load. After the sink rolls were realigned and bearing tolerances increased, the line operated according to expectations.

The strip tension compounding theory was checked by removing power from motors in groups of eight at the entry, center, and delivery portions of the processing section, and noting the load change on the main pulling bridle. When the first eight motors in the processing section were electrically disconnected, it was discovered that the load on the drive bridle increased by an equivalent of three times the power removed. Reapplying the power to the first group of eight motors and removing power from the center group of eight resulted in a load increase on the drive bridle equivalent to double the power that had been removed. When power was removed from the exit group of eight motors, the bridle load increase equalled only that of the power removed.

Protection for the helper drive motors was provided by using water-tight, three-pole manual starters mounted in small groups close to the motors. This mounting arrangement made it convenient for the operators to select roll drive combinations for threading.

Most modern production lines operate over such a wide speed range that it is impractical to apply a-c helper drive motors, particularly if the adjustable-frequency alternator type of system is employed. By the time provisions have been made for speed and torque control, plus the conversion from a-c to d-c and back again to a-c the adjustable frequency system often results in a higher first cost than for a complete d-c system. The probable increased maintenance cost of d-c motors over the a-c motors, cannot always justify the possible greater initial expenditure for an a-c system. It is recognized that other types of a-c drive systems other than the alternator might be employed. It is doubtful, however, that these systems would prove to be less expensive than a comparable d-c system, by the time necessary operating characteristics are provided. The fact that we have built more d-c drive systems than a-c in a ratio of six d-c to one a-c is quite indicative of the trend.

The inherent constant-torque characteristic of the d-c motor basically satisfies the requirement of the helper drive. To obtain the necessary load sharing and continual tugging characteristic, the addition of slightly more than normal series or compound winding is all that is required. Compound winding is normally selected to produce approximately 15 per cent speed drop from no-load to full-load when the motor is operating at its maximum theoretical geared-in speed. Motor sizing to some degree dictates the degree of compounding, for

if the motor is oversized for the application, increased compounding would be necessary to assure load sharing at light loads.

A rule of thumb estimate for determining helper drive horsepower is to first determine the horsepower necessary to accelerate the roll or rolls in the prescribed time, assuming 100 per cent accelerating torque maximum from the motor. Final horsepower for lines operating up to 800 fpm will be estimated by multiplying the calculated horsepower by two. For lines operating up to 1500 fpm, the resultant horsepower is obtained by multiplying by three. These horsepower calculations are, of course, only approximate and require modification for special bearings or for extraneous frictional components involved. During steady state operating conditions, it would be expected that at least 80 per cent of the horsepower rating of the motor selected could be applied to overcome frictional and pumping losses.

All but one of the d-c drive systems installed utilize d-c gearmotors as the helper drive medium. Economics, space limitations, and roll diameters influence the application. This one other line utilizes conventional foot-mounted and floating motors.

Splash-proof motors were utilized on two of the systems where line speed was varied only over a very narrow range. Other systems utilize force-ventilated motors and totally-enclosed non-ventilated motors. Physical limitations and economics from a first cost standpoint tend to dictate the application of motors other than the totally-enclosed non-ventilated type. However, totally-enclosed, non-ventilated motors are strongly recommended because of their inherent provision for operating speed ranges, poor atmospheric conditions, and high short time overload capacity.

Figure 1 shows the installation of twenty-six d-c gearmotors applied as helper drives to conductor rolls on a tinning line capable of speeds up to 1500 fpm.

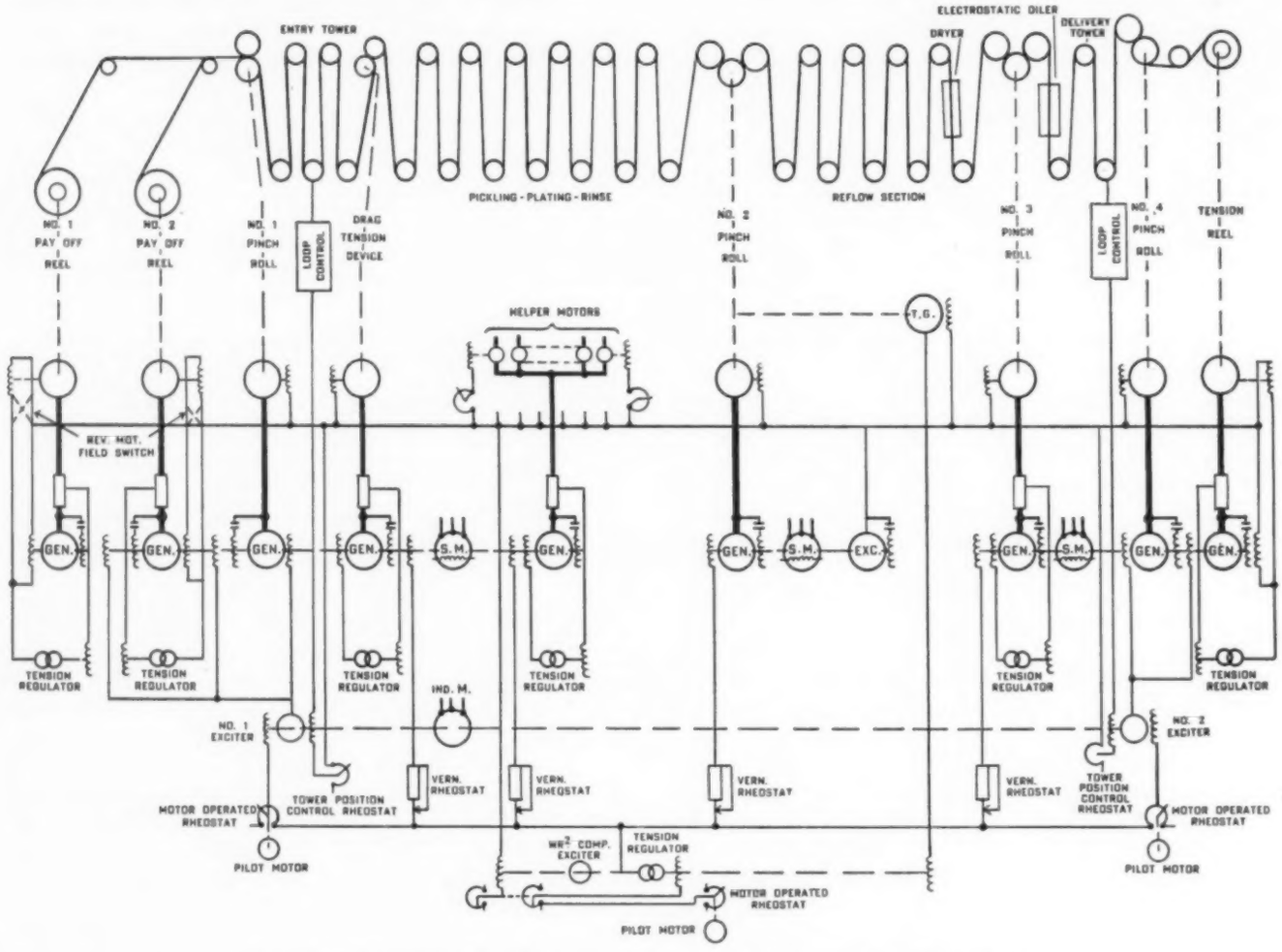


Figure 3 — Diagram shows schematic operation of electrolytic tinning line.

Motors for this application are force-ventilated. To the left you will notice the floor mounted vertical operator's station having mounted thereon ammeters, field adjusting rheostats, and four-pole circuit breakers with field discharge resistors for controlling the helper gearmotors. The circuit breaker opens all four leads to the motor to completely disconnect it from the power source in case of overload resulting from loss of field, or actual mechanical loading. Close proximity of this panel to the line enables the operator to select motor combinations for threading. The rheostats and ammeters are used to maintain motor load matching.

Figure 2 shows another method for protecting and disconnecting helper drive motors. A thyrite discharge resistor is mounted within the oversize conduit box and is connected across the field terminals. A four-lead cable connects the conduit box with a four-pole male or female plug. The two armature circuit poles have fuses inserted

in series within the cable end plug enclosure. Rigidly mounted outlets mounted close to the motors complete a protective combination that is inexpensive, provides adequate protection, and furnishes a ready means for motor disconnect. With this combination, relatively small wall mounting type boxes are provided for the ammeters and rheostats.

On three installations, a very elaborate system of helper drive motor protection and control was involved. Mounted on factory assembled control panels, there was provided for each motor a single-pole armature circuit knife switch, two-pole field disconnect switch with discharge resistor, field loss relay, overload relay, single-pole main line contactor, ammeter, and a field adjusting resistor. In addition to individual motor protection, control was also provided for sectionalizing the helper drives in groups. This consisted of magnetic control components, selector switches, and pushbuttons to provide pre-selected group jogging for threading. These latter two protective systems are just about the extremes in each direction.

As previously mentioned, helper drives are basically a constant-torque application. Any torque modifications should be in a direction to increase torque with increase in speed. Torque variations to suit operating conditions can easily be obtained by applying appropriate correction in a regulating system that should invariably be applied to control the field of the booster or generator supplying adjustable-voltage power to the helper motors. Torque or current regulators assure the ability to apply torque from rest to help start the drive, and permits a simple application of WR^2 correction so necessary for speed changes. In all cases, the helper drive system should always anticipate a change in strip speed. If the system does not do this it becomes a follower rather than a helper, in which case the necessity for the helper drive application becomes doubtful. Another important advantage of the torque regulator is that it provides the operator with a simple means for adjusting torque level, and relieves him of the necessity for repeated monitoring to assure maintenance of the desired torque level.

When helper drives are applied to processing lines requiring partial line speed coverage with constant horsepower applied by the main propulsion drive motors, it is necessary to apply an individual generator for the group of helper motors. A tachometer generator driven by one of the main strip propulsion drive motors can be used to excite the main field of the helper drive generator to establish the basic generator voltage-line speed relationship. An auxiliary field on the generator should be controlled by a torque regulator so that the regulator will modify the generator voltage to maintain the pre-set torque value. Such a system is shown in Figure 3, and was applied to the helper drive system shown in Figure 1. If the basic drive system requires constant torque, boosters might be used in conjunction with the helper drive system, if adequate booster voltage range is available. A system of this type is shown in Figure 4.

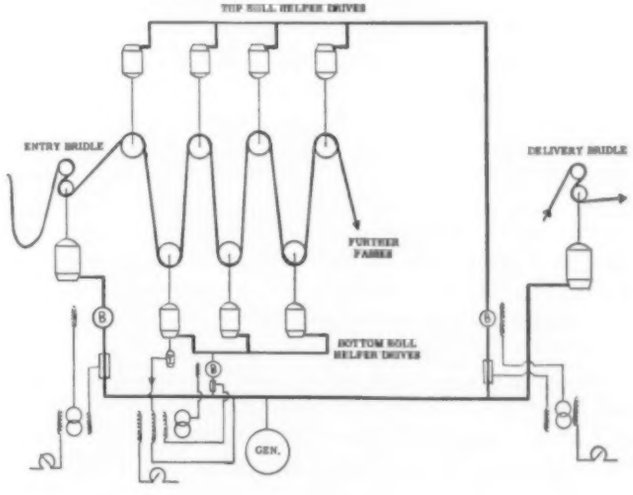
Note in this figure there is indicated a helper drive system for sink or solution submerged rolls as found on cleaning lines and electrolytic tinning lines. Sink roll helper drives differ from non-submerged roll helper drives because of lower, and frequently complete loss of frictional contact between the strip and the surface of the roll.

We were associated with a sink roll helper drive application installed on a tinning line approximately six months ago. Recently, helper drive characteristics were checked and evaluated. The following important facts were disclosed:

1. Slippage did not occur between the conductor roll and the strip when the equivalent of five times normal torque was introduced to the roll.
2. At standstill, no slippage occurred between the sink roll and the strip when three times normal torque was applied.
3. Strip and sink roll contact is lost at between 350 and 400 fpm, depending upon the degree of entry tension.
4. When operating the line above 400 fpm, the speed of the sink rolls was varied above and below actual strip speed as much as 25 per cent to determine whether differential speed between these two surfaces had any detrimental effect on the tin plate quality. It was found that there was definitely no quality impairment resulting from speed differential. It was concluded that at speeds greater than 400 fpm there must be a complete solution barrier between the surface of the roll and the strip. This conclusion was verified when we watched the helper drive motor loading during speed change above 400 and below 350 fpm. It was concluded that regulating control for sink roll helper drives should be the torque control type to assure starting and acceleration from rest. Also, an overspeed supervisory system was required, in addition to torque control, so that when contact was lost between surfaces, the surface speed differential would not be important. It was felt that maintenance of approximately the same speed was important to prevent possible strip marring when the solution barrier between the two surfaces was lost on deceleration. The sketch indicates the tachometer spill-over feedback circuit tied into the regulator to maintain this approximate speed matching.

Helper drive characteristics for cleaning lines essen-

Figure 4 — Boosters are used in conjunction with the helper drive system.



tially duplicate the requirements for conductor and sink roll drives on the tinning line.

For annealing furnace helper drives, the system would basically duplicate that applied to the conductor roll helper drives except that helper drive motor compounding would be increased, and Class B insulation added to accommodate the potentially higher ambient and conduction temperatures.

Progress, expansion, and modern ideas have brought the steel industry to its present position. As it has become modernized, and more efficient, even more efficiency is required for higher production and lower costs. An important phase of this lies in the ability to combine processes for continuity of operation and to conserve ever-valuable floor area. Helper drives perform a valuable service in the accomplishment of both of these functions with extremely satisfactory results.

DISCUSSION

PRESENTED BY

A. R. GEISZLER, Application Engineer, The Wean Engineering Co., Inc., Warren, Ohio.

C. C. THOMAS, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

A. R. Geiszler: Mr. Vonada indicated the basic reason that helper drives have become necessary is to minimize floor space occupied by the increasingly complex and higher speed processing lines by causing the strip to pass vertically through the units. It may be of interest to point out exactly how much floor space is saved by using vertical passes. The electrolytic tinning line at the Kaiser Steel Corp., Fontana Plant, has an overall length from centerline of No. 1 coil holder to centerline of prime piler of approximately 260 ft. However, had horizontal tanks been used and all installed at floor level, this line would have an overall length of nearly 500 ft. With such a saving in floor space the industry will always be confronted with the necessity of using deflector rolls.

I would like to amplify one point brought out in the paper pertaining to the application of strip propulsion help in large power blocks. Mr. Vonada's analysis of increased bearing friction losses is entirely correct assuming, of course, that the bearings are not properly selected for the increased loading. There is, however, another means of providing a drive to the numerous deflector rolls without using individual roll drive motors and not encounter these high bearing loads. This can be accomplished by using a larger motor and mechanically coupling it through V-belts, sprocket and chain, or line drive shafts to a multiplicity of deflector rolls having similar loading characteristics. Such a system is considerably less expensive, but it imposes a restriction on the use of the equipment which is not encountered with the use of individual roll drive motors, that is, the diameters of all rolls connected into each drive must be very closely matched. Any mismatch in roll diameters connected into such a drive would result in some slippage between strip and rolls. Just what effect on the operation of a line such a slight mismatch in speed may have depends to a great extent on the process involved and the location of the rolls. There have been a considerable number of installations using this type of drive without any form of regulator other than the inherent regulation of the motors mentioned by Mr. Vonada. We are now in the process of installing torque regulators on a dry roll drive system of this type and speed regulators on a submerged roll drive system such as this. To the best of our knowledge, this is the first application of a speed regulator to this type of drive and the installation will be observed with great interest.

C. C. Thomas: When the first continuous electrolytic tinning lines were installed about 1943, it soon was apparent that there was a limit to the number of "idle" rolls a steel strip could be threaded around and still pulled from one point. Obviously one limit was the breaking point of the strip and should have been easy to calculate. It was also almost obvious that, if the strip wraps around 25 rolls and each requires say 2 hp to bend the strip and run at rated speed, one main pinch roll should be able to pull them from one point with 50 hp. The fallacy in this reasoning was discovered in 1943 when it was found that the power required to pull from one point was equal to several times the sum of the powers required to pull from separate points. This effect Mr. Vonada has called "compounding." Because of this effect, designs of continuous lines had to be modified so that excessive horsepower and tension did not exist at one point, and cause strip breakage. This accelerated a trend toward multiple drives with more rollers being driven by separate or group drives depending on the particular mechanical arrangement.

The "ideal" or ultimate, of course, would be to have a separate motor and a separate regulator for each roll. This would enable each motor to provide just the right amount of torque to the roll so that no tension would be added to or subtracted from the strip as it bends around the roll. This ideal system could be built too, but it would require a control with the approximate complexity of that used on the most exacting 7000-fpm tandem cold strip mills and naturally would be much too expensive.

Therefore any system which is selected to help drive these rolls must necessarily fall in between two cases; (1) no drive and maximum tension changes, and (2) individual drive and minimum tension change.

Our most recent "helper roll drives" have used an individual d-c motor per roll. Each motor has a small tapped armature resistor in series to assure load division and simple adjustment. Each group of these motors is then supplied through a series excited booster generator to compensate for the difference in the IR drop of the helper roll motors and the main pinch roll motor, all of which are supplied by the same adjustable voltage generator. This system does not assure that each motor contributes exactly its proper share of torque, but it is simple and inherently gives the proper results without a regulator. This system is now in successful operation on the new 1000-fpm continuous tinplate annealing lines at Gary Sheet & Tin and Fairless Works. Here the application is in some respects more difficult than on an electrolytic tinning line because the strip is hot and easily broken.

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BLAW-KNOX

TWO-HIGH / FOUR-HIGH COMBINATION MILL AIDS ROLLING RESEARCH

By A. I. NUSSBAUM
Rolling Mill Division
Stanat Manufacturing Co.
Long Island City, N. Y.

▲ TODAY'S important developments in the field of new engineering materials have led to much experimental hot and cold working being performed by both the producers and consumers of metals and alloys. In the Pittsburgh area alone, major metallurgical research and pilot production centers are currently being built by such leading organizations as U. S. Steel, Jones & Laughlin, Allegheny Ludlum and Westinghouse. Much of the development work undertaken by such research groups involves fundamental studies of rolling performance and requires facilities for hot and cold working of experimental ingots, billets, bars, shapes and strip.

With modern ferrous materials ranging from ductile low carbon steel to such hard-to-deform alloys as stainless and silicon steels, an extremely wide range of loading is imposed upon the rolling mill equipment that is required to work some or all of these materials from initial ingot breakdown to strip finishing at ultra-thin gages in the neighborhood of 0.001 in. The resulting equipment problem can be solved easily in the case of high-production plants, where the quantities processed justify the installation of a series of rolling mills to take the produet through the several stages of hot and cold reduction. However, the many research laboratories and metallurgical pilot plants which are today faced with processing carbon and alloy steels in experimental quantities clearly cannot afford the range of individual mills normally required to take an ingot of, say, 2 in. thickness down to 36 gage strip. Furthermore, it has been found time and again that it is impractical to perform experimental rolling work on production mills. Such test runs usually interfere with plant production schedules, and may cause much friction between a company's mill personnel and research staff. Thus, there exists a need today for a high precision mill capable of performing the widest possible range of bar, rod and strip reduction, available at a price within the reach of the usually limited budgets of research organizations and designed in the most compact manner to fit into the often restricted space of metallurgical laboratories. The two-high/four-high combination mill has been developed to fill this need.

TWO-HIGH OPERATION

When functioning as a conventional two-high unit, the mill has a relatively large work roll diameter which is valuable for the breakdown of ingots and bars, and in skin pass rolling of annealed strip, when it is usually desired to take a reduction of only about 1½ per cent. Similarly, such rolls are employed with advantage when reducing strip with little or no lubricant to obtain a bright and highly burnished surface finish. This luster effect is directly due to the fact that the larger the work roll diameter the greater the amount of slipping between the roll surface and the material.

Finally, the two-high mill configuration is still largely preferred for the rolling of mirror-finish strip using extremely hard and close-grained rolls super-finished to RMS values of 1 micro-inch by means of diamond compound lapping. In such ultra-precision work it is not desirable to have the continuous line contact between the work and back-up rolls, and wiping of the work rolls with the aid of felt pads is more readily effected in the two-high design. Furthermore, a larger diameter work roll with its greater circumference is subject to relatively less wear and thus offers longer satisfactory performance between regrinding.

Figure 1 — Ingot can be rolled on 2-high mill setup.

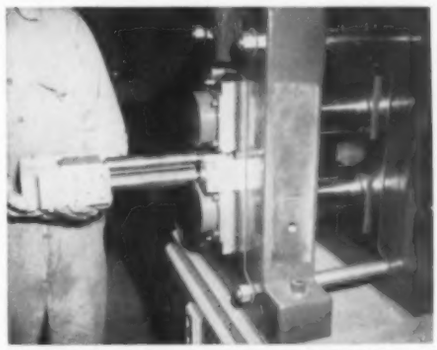

Figure 2 — Changeover to 4-high mill setup is easily made.

FOUR-HIGH OPERATION

Almost every engineer or metallurgist using two-high strip mill equipment sooner or later runs into difficulties by the inability of his completely screwed-down mill to produce any further gage reduction. In such a case, even a further intermediate

(*Please turn to page 202*)

Proven On loads *UNDER* 600 Amps . . . .

Fusetron dual-element Fuses Have an Interrupting Rating in Excess of 100,000 Amps.

An interrupting rating in excess of 100,000 amperes for FUSETRON dual-element fuses . . . this was shown by tests that were conducted under conditions that simulated the most severe field conditions. These tests were witnessed and verified by the Electrical Testing Laboratories of New York.

The test circuits were set to deliver far in excess of 100,000 amperes — yet the 250 and 600 volt FUSETRON fuses cleared the shorts without igniting readily flamable material placed around the fuses . . . and there was comparatively little noise.

These tests show that Fusetron fuses, even in the small 30 ampere range, can interrupt safely the most severe available short circuit current.

No interference with time-lag

Time-lag is of utmost importance to give proper motor and electrical protection and to eliminate needless blowing of fuses. Even though the interrupting capacity has been greatly increased, the time-current characteristic of Fusetron fuses has in no way been disturbed.

ALL THIS ADDED SAFETY

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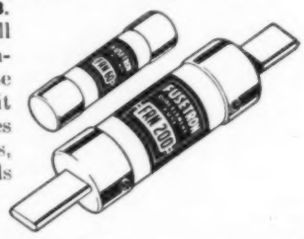
1. Protect against short-circuits. **2.** Protect against needless blows caused by harmless overloads. **3.** Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation. **4.** Provide thermal protection — for panels and switches against damage from heating due to poor contact. **5.** Protect motors against burnout from overloading. **6.** Protect motors against burnout due to single phasing. **7.** Give double burnout protection to large motors — without extra cost. **8.** Make protection of small motors simple and inexpensive. **9.** Protect against waste of space and money — permit use of proper size switches and panels. **10.** Protect coils, transformers and solenoids against burnout.



Fusetron Fuses Help eliminate needless Shutdowns for Production Engineers.

Work stoppages caused by needless blows are prevented. Even if all the motors on a circuit start at one time or other harmless overloads occur, the fuse link holds to prevent a shutdown.

Likewise, Fusetron fuses guard against needless blows caused by excessive-heating in panelboards and switches—lesser resistance results in cooler operation.

Fusetron Fuses Offer Maximum Safety for Electrical and Safety Engineers.

With an interrupting rating of 100,000 amperes, Fusetron fuses give the greatest possible protection against damage due to short-circuits. And just as important, they reduce the hazard of motor burnouts due to single phasing and overloading.

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Once properly installed, Fusetron fuses require no costly inspection time or down-time for calibration and other maintenance necessary on mechanically operated devices.

Unnecessary repair work on motors is avoided because Fusetron fuses reduce to a minimum the danger of damage due to electrical faults. If trouble occurs, instead of rewinding or replacing burned out motors, simply replace Fusetron fuses.

Switches and panelboards are protected against damage from poor contact heating.

Fusetron fuses also protect against needless blows that cause irritating interruptions of regular maintenance.

Proven On loads *ABOVE* 600 and up to 5,000 Amps.

BUSS Hi-Cap Fuses Have an Interrupting Rating In Excess of 100,000 Amps. . . *and their blowing time can be coordinated with that of Fusetron fuses.*

An unlimited interrupting rating for BUSS Hi-Cap fuses on any voltage up to 600 . . . this was confirmed by tests reported by the Electrical Testing Laboratories of New York.

BUSS Hi-Cap fuses are designed to give protection against dangerous overloads as well as high fault currents — yet retain the speed of operation necessary to limit heavy short currents to safe values.

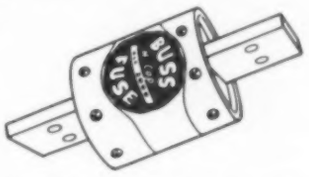
When coordinated properly with Fusetron dual-element fuses they will not open ahead of the fuse nearest to the fault — thus the trouble is isolated to the part of the circuit in which the fault occurs.

Added SAFETY on Old Installations

On installations where the increase in the capacity of the circuit has outgrown the interrupting rating of the circuit breakers, BUSS Hi-Cap fuses offer a safe and relatively inexpensive way to protect inadequate breakers against rupture in event of bad fault.

ACTION THAT SAVES YOU MONEY

Don't risk losses. Delay may cost you far more than replacing every fuse with a FUSETRON fuse. By passing the word along that all purchase and stock records should call for FUSETRON dual-element fuses on loads up to 600 amperes — and BUSS Hi-Cap fuses on loads above that, you get action that begets money saving.



On New Construction tell your architect to specify this Safer, Better Protection.

Fusetron Fuses Cuts Cost for Top Management.

Cuts maintenance cost — Fusetron fuses are maintenance free.

Cuts motor repair cost — Fusetron fuses guard the motor, against damage due to overloading, single phasing, short circuits and other electrical faults.

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(*Continued from page 199*)

anneal often is of little help, and the only solution is to continue processing the strip on four-high or cluster mill equipment having considerably smaller work rolls backed up by large supporting rolls. The concept of a two-high/four-high combination mill was developed particularly to overcome this situation. Depending on the application of such a machine, it may be considered primarily as a two-high mill designed so the rolls can be raised sufficiently to allow the insertion of a set of two small diameter work rolls.

All forms of backed-up rolling mills have for their object the largest practical reduction in the diameter of the work rolls. Extensive research into the cold rolling of strip has established that — for a given material, reduction and width — the roll load, rolling torque, rolling horsepower and lateral spread of the strip decreases with the diameter of the work rolls. Consequently, for a mill of given roll load capacity and horsepower, greater reductions may be taken with work rolls of smaller diameter. The reduction in lateral spread with reduction in work roll diameter also has considerable practical advantage in the rolling of the harder metals and alloys, as it reduces the tendency of the strip edges to tear or crack. The "stiffness" of the backed-up four-high mill and the ease with which its small work rolls can be crowned have made possible the production of extremely accurate strip having practically no gage variation across its width. Finally, a smaller work roll allows thinner strip finishing gages to be obtained, even in highly work-hardened materials since the length of the flattened arc of contact between the work rolls and material — and, hence, the roll load and rolling torque — decreases with decrease in work roll diameter. In this respect, a reliable rule of thumb indicates that the minimum practical finishing gage is equal to one-thousandth of the work roll diameter.

An interesting illustration of the latter phenomenon may be obtained by comparing the roll load and the rolling torque involved in reducing Type 302 stainless steel strip from 0.015 in. to 0.012 in. in a width of 6 in. using (a) the 8 in. × 8 in. two-high configuration, and (b) the 2 in. and 8 in. × 8 in. four-high roll setup. The calculations required were performed using the method of Bland and Ford, which allows for the effect of roll flattening, being based in this respect on Hitchcock's formula. See "Applied Mechanics," by D. R. Bland and H. Ford, Proc. Instn. Mech. Engrs., vol 159 (1948), pp 144-163. The calculations assumed (a) rolling without tensions; (b) a 1.15×84,000 psi constrained mean yield stress of the material being rolled following an intermediate anneal; (c) rolls made of steel for which Young's Modulus of Elasticity = 30,000,000 psi and Poisson's ratio = 0.3; and (d) a coefficient of friction between rolls and strip of 0.10. See Table I.

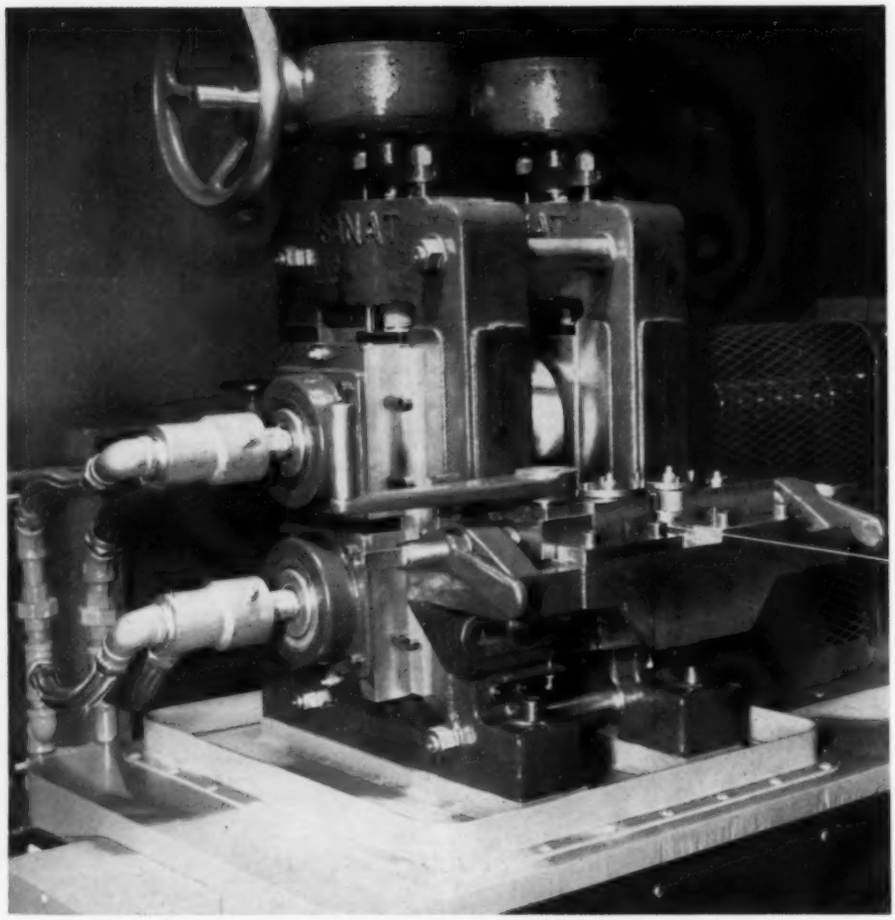


Figure 3 — Mill can be arranged with vertical edger and rotary unions.

It is evident from the above tabulation that the great reduction in roll load and rolling torque made possible by the four-high arrangement is largely due to the small diameter work roll being much less subject to flattening in the arc of contact. The reduction in roll load and rolling torque may be made even greater by employing tungsten carbide work rolls. Cemented tungsten carbides have a modulus of elasticity twice to three times that of steel and thus tend to reduce roll flattening to the very minimum now obtainable.

MILL DRIVE

Depending on the required range and speeds of reduction to be performed, the two-high/four-high combination mill may be powered by a constant speed a-c motor, a four-speed gearshift a-c motor, an eddy-current clutch variable speed a-c drive, or a Ward-Leonard variable

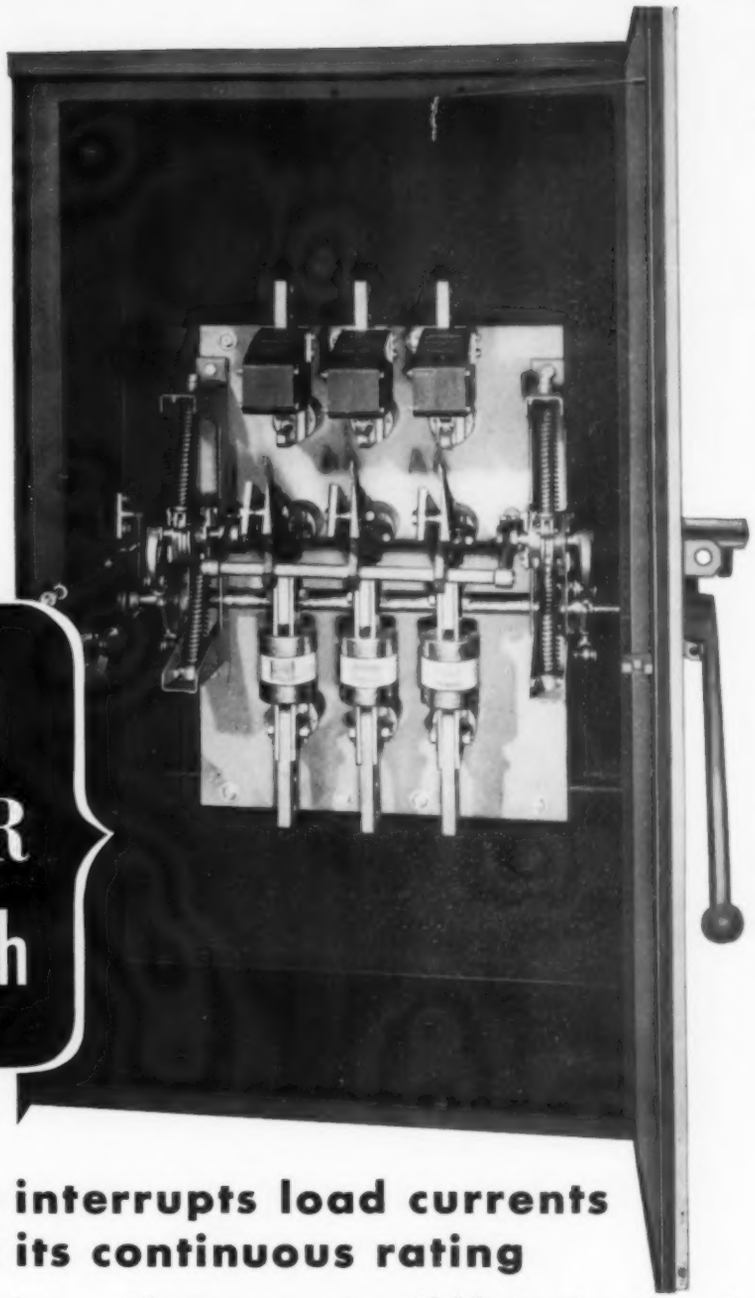
TABLE I

Mill arrangement	Radius of undeformed work roll, in.	Radius of deformed work roll, in.	Roll load, lb	Rolling torque per roll, lb-in.
8 in. x 8 in. Two-high	4	10	202,000	65,000
2 in. and 8 in. x 8 in. four-high	1	1½	49,000	975

Another DELTA-STAR Safeguard for Steel Mills

These rugged disrupter switches meet a long-felt need for a switch to safely interrupt heavy load currents. Combining the function of a disconnect and load interrupter, they are ideally suited for opening large motor circuits or for branch feeder control.

Illustrated is a 600-volt, 1200 ampere DELTA-STAR Disrupter Switch with current limiting fuses.



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safely, positively interrupts load currents several times its continuous rating

These switches feature a quick-break, quick-make mechanism which places opening or closing speeds beyond the operator's control. DELTA-STAR'S exclusive arc interrupting chambers, one mounted on each pole, quickly and positively extinguish the arc.

An auxiliary contact on each switch blade opens circuit inside the especially designed arc chute. The arc is broken and cooled by being directed into vents — contacts are protected against burning and pitting.

Heavy gauge steel cabinets provide maximum protection of operating parts. Continuous welded seams and weathertight gasketed doors exclude dust and corrosive particles. Liberal gutter space is provided for incoming and outgoing conductors.

Cabinet door is mechanically interlocked so door cannot be opened when switch is closed, nor can switch be operated when door is open. Provision for padlock eliminates unauthorized operation.

DELTA-STAR Disrupter Switches are available in continuous current ratings of 400, 600, 1200, 2000 and 3000 amperes. To protect the electrical system from magnetic or thermal destruction, switches are also available with high interrupting current limiting fuses which prevent development of peak short circuit currents.

For complete data, consult your nearby DELTA-STAR *representative.*

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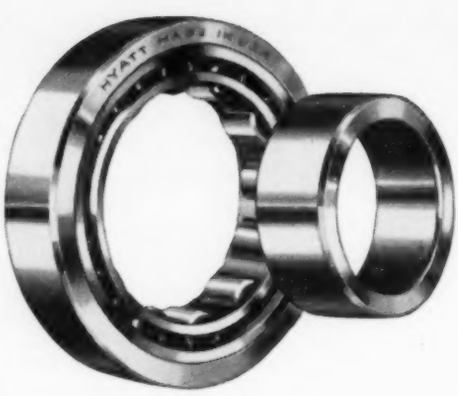
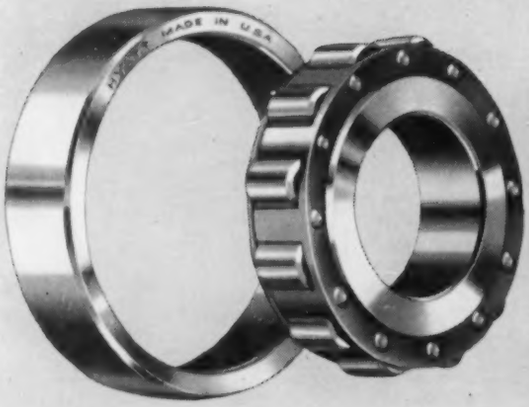
3 ways to handle your RADIAL LOAD PROBLEM



1 If your design requires a large shaft diameter to produce greater rigidity without disturbing boundary dimensions, a separable inner race type Hyatt Hy-Load bearing can be used with the inner race omitted. Rollers operate directly on a suitable hardened and ground shaft.



2 When the housing bore must be kept to a minimum, a Hyatt Hy-Load bearing with a separable outer race can be used—with the outer race omitted. The rollers then operate directly in a housing bore of suitable hardness and finish.

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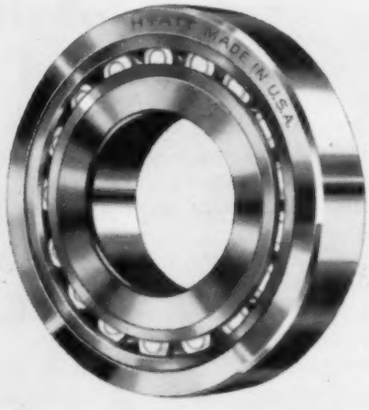
If your design applications involve radial loads, the best way to handle the job is with Hyatts—for Hyatt offers industry's most complete line of straight radial roller bearings! Hyatt Hy-Loads, for example, are made in three diameter series and two basic widths, to standard dimensions. There are ten major types—for the heaviest radial loads, and light or intermittent thrust loads. Four have separable inner races, two have separable outer races and four are non-separable, thus permitting wide flexibility in design and assembly procedures. Write for our general catalog No. 150—it will put the solution to any roller bearing problem at your fingertips, Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



3 For designs requiring a bearing installed as a unit, there is the non-separable type of Hyatt Hy-Load. Whether you select a separable or non-separable type of Hyatt Hy-Load, they are available in a wide range of sizes.

HYATT

ROLLER BEARINGS

STRAIGHT BARREL TAPER

speed d-c drive. Similarly, the method of providing front and back strip tension may be varied in accordance with maximum strip pull requirements and coil build-up ratios. In the simplest arrangement on a non-reversing mill, back tension is applied by means of a friction brake on the pay-off reel, and variable front tension is obtained by driving the coiling reel from the main mill motor through an adjustable slipping clutch. On the other hand, a reversing mill may have a variable speed constant tension regenerative drive with d-c equipment on the mill and both reels. The improved reductions and strip flatness obtainable with the application of front and back tensions is of particular importance in cold-working thin, hard metals, and in the processing of these materials, tensions equivalent to ⅓ to ½ of the yield stress of the strip are frequently employed.

The mill motor is generally mounted in the unit base of the machine and drives the pinion stand through herringbone reduction gearing. The mill pinions have herringbone teeth and drive the two large diameter rolls through spindles equipped with heavy-duty universal joints. The lower spindle can be arranged to incorporate a torque meter allowing a continuous record of rolling torque to be obtained during operation of the mill. Similarly, provision has been made for load cells to be placed between the upper chocks and the roll adjusting screws, so that the respective roll loads can be indicated continuously.

In an "all-purpose" mill of the type being discussed, there is much to be gained from driving the back-up rolls rather than the work rolls. While originally there was objection to this method on the grounds that slippage would occur between the work rolls and the back-up rolls, the extensive and successful service of back-up driven four-high mills in both the ferrous and non-ferrous industries has proven the soundness of this design. The back-up drive eliminates one of the most serious disadvantages of the conventional work roll driven four-high mill: the limitation in torque that can be transmitted by the relatively small roll necks and spindles without exceeding their permissible torsional shear stress. This limitation is particularly serious in the case of carbide rolls which have a comparatively low torsional strength. Another valuable feature of the back-up drive is its ability to overcome the lateral bowing out of the small work rolls when heavy reductions with high front tension are being taken. Driving the back-up rolls causes a torque reaction on the work rolls which tends to bend them toward the entry side of the mill, i.e., in the opposite direction to the force exerted by the coiling reel. By balancing this torque reaction and the strip tensions, the tangential force on the work rolls can be eliminated altogether.

MILL STAND

The housings of the two-high/four-high combination mill are high-strength iron or steel castings mounted on a unit base of fabricated steel plate construction. The housing posts have been designed with exceptionally large cross-sectional areas to obtain an extremely rigid mill capable of handling severe roll loads without undue deflection. Depending on the size of the mill, either a mechanical or a hydraulic roll lift method is employed. By the use of exchangeable shim plates, the vertical center line through the work rolls can be moved either ahead or to the rear of the back-up roll center line. The single handwheel screwdown is manually operated and is equipped with a simple clutch device to allow roll parallelism correction. The opening of the rolls is indicated in 0.0001 in. by micrometer dials directly connected to the screwdown mechanism.

The standard rolls for the mill are made of close-grain alloy steel, hardened to Rockwell C-64 minimum, and ground and lapped to a mirror-finish. When used as a conventional two-high unit, the mill may be equipped also with grooved rolls for the reduction of round, square and other shapes. Furthermore, both flat and grooved rolls are available in either chilled iron or in a special "hotform" alloy steel which allows hot rolling to be performed over a roll temperature range up to 1000 F. For heat dispersion purposes in hot rolling, the mill may be equipped with a self-contained bearing lubricant circulating, cooling and filtering system. Moreover, to facilitate internal cooling, water may be circulated through the rolls having a central cavity, fitted with rotary unions and flexible hose lines.

In rolling the heavier gages of strip, it is frequently necessary to edge-condition the material. This operation may be combined with the actual reduction in the mill by mounting a vertical edging stand at the entry or exit side of the machine. The stand has hardened alloy steel non-driven rolls equipped with a number of grooves to match the required edge shape and is furnished with a cam-operated quick-acting roll opening device.

MILL PERFORMANCE

In an effort to establish the performance characteristics of the two-high/four-high combination mill, extensive rolling tests were conducted recently on a 1½ and 5 in. × 8 in. mill equipped with a 10-hp four-speed gearshift drive. The materials which were reduced successfully in the course of these tests included carbon steels, stainless steels, silicon steels, titanium alloys, nickel-iron magnetic materials, hastelalloys, inconel-X and other "superalloys." Table II shows the results of a representative pass sequence in the cold reduction of inconel-X strip on this mill.

TABLE II

Material: Inconel-X
Initial size: 0.099 x 3 in.
Initial hardness: Rockwell B-89
Initial tensile strength: 125,000 psi
Rolling speed: 35 fpm

A. Two-high operation

Pass No.	Thickness	Per cent reduction
1	0.074	25
2	0.059	20
3	0.049	17
4	0.041	16
5	0.035	15
6	0.030	14

B. Four-high operation

Pass		
7	0.026	14
8	0.022	15
9	0.019	14
10	0.0165	13
11	0.0145	12
12	0.013	11
13	0.0115	11
14	0.0105	10
15	0.0095	9
16	0.0088	8
17	0.008	8

Thus, the machine was able to effect a total reduction of 92 per cent in 17 passes without any intermediate anneals.

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. . . and get complete engineered installation of mill equipment for basic industry, including design and construction of foundations and buildings therefor. Unbiased and quick-witted, the McDowell Method sells no product, but delivers its jobs ready-to-operate, and welcomes turnkey responsibility.

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Electrical Equipment for new Planetary Rolling Mill

. . . . mill will reduce 1¾-in. slab to 0.040-in. in one pass . . . .

▲ ONE of the first planetary rolling mills to be put into operation, at Wednesfield, England, is designed to roll approximately 10 tons of various grades of steel each hour. The rolling operation is continuous and steel slabs 15 in. wide by 1¾ in. thick can be reduced to strip 0.040 in. thick in one pass. This exceptional reduction is made by a single stand having two 24-in. diameter rolls surrounded by 26 planet rolls, each 2 in. in diameter. The inner rolls are driven at a speed of 500 rpm, driving the planet rolls by friction so that the cages revolve at 228 rpm. The planet rolls, therefore, move over the wedge-shaped end of the slab, which is moved forward by feed rolls so that a reduction of about 0.015 in. is made as each planet roll passes over the end of the slab. It is possible to vary the ingoing speed of the mill between 4½ and 9 fpm, and the outgoing speed of the strip between 66 and 200 fpm.

The slabs are first heated in a continuous furnace to a temperature of about 1380 F. The furnace comprises a number of heating and soaking sections, through which the slabs are passed on water-cooled rolls, driven at the ingoing mill speed.

To maintain the continuity of the forward thrust, the slabs must be butted end-to-end. A set of pinch rolls between the feed rolls and the furnace runs slightly faster than the mill. When a gap occurs between two slabs, the pinch rolls are closed to accelerate the following slab.

The planetary rolls leave a slight ripple mark on the strip. To give an improved surface, a small reduction in thickness is made in the 24-in. planishing mill which follows the planetary rolls.

After passing through the planishing mill, the strip cools on an 80-ft run-out table and is coiled in a 3-roll coiler.

The main advantages of the planetary mill over the orthodox arrangement are:

1. The maximum reduction per pass of not much more than 30-40 per cent in an orthodox mill would mean about half a dozen passes each, on reversing, roughing and intermediate mills, with a four or five stand tandem finishing mill. The planetary mill therefore offers much saving in plant and building size.
2. To reduce heat loss during rolling, the finishing speed of an orthodox mill would be, say, 2000 fpm. For an output of, say, 10 tons per hour, the planetary mill could roll at 200 fpm. The load factor of the orthodox mill would therefore be about 10 per cent against about 100 per cent for the planetary mill, resulting in smaller machines, greater overall efficiency and reduced power costs for the planetary mill.
3. The heat loss during rolling would mean an initial slab temperature of about 2000 F, for an orthodox mill against 1380 F for the planetary mill. The lower temperature means much less scale formation on the planetary mill and consequently improved quality of strip surface.
4. The tail end of the strip on the final pass on an orthodox mill is somewhat cooler than the leading end due to a longer period of heat

Figure 1 — Outgoing side of planetary rolling mill shows control desks facing the mill and above the rolls from right to left, the screwdown motors for the feed rolls, planetary rolls and planishing rolls.

Figure 2 — Motors drive the pinch rolls, feed rolls, planetary rolls and planishing rolls of the mill. The feed roll screwdown motor can be seen on the extreme left.

loss. As a result it may be appreciably thicker after rolling. The planetary mill's continuous action gives an even temperature, resulting in consistent thickness throughout the strip.

The electrical equipment for the main and auxiliary drives was supplied by the English Electric Co. Limited.

The d-c supply for the motors is taken from an English Electric motor-generator set having three generators and various exciters driven by a 365-hp, a-c, synchronous-induction motor arranged to give an overall power-factor for the mill of not less than

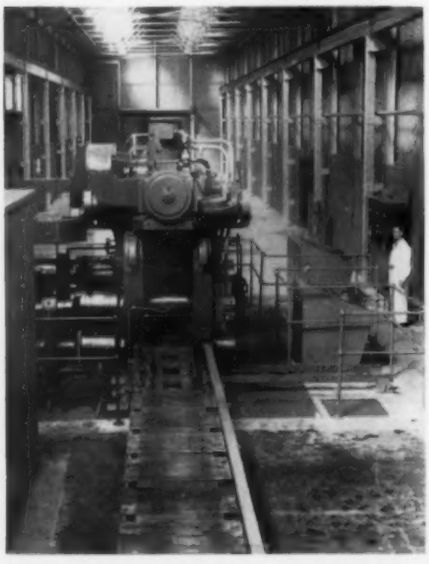


Figure 3 — Outgoing side of planetary rolling mill shows control desks facing the mill and screwdown motors on top of mill.

0.95 lagging. The motor-generator set and the automatic control gear are installed in a specially ventilated room, while the mill motors, which are installed in the rolling bay itself, are forced-ventilated to exclude airborne dust. Details of the motors supplied are given in Table I.

The pinch rolls are designed to run at a speed slightly faster than the entry speed of the mill. They are normally open, but are engaged by hydraulic cylinders to the leading edge of each slab to ensure that no gaps exist between slabs before the feed rolls are reached. The feed roll drive is arranged to push the slabs into the planetary roll bite against a thrust of up to 11 tons set up by the rolling action. The pinch and feed roll motors are supplied from a common Ward-Leonard generator.

A slip-ring induction motor drives the planetary rolls continuously at a constant speed, and is controlled by a circuit-breaker and hand-operated liquid starter. To ensure rapid stopping in an emergency, a thruster-operated brake is fitted and is operated by the common emergency stop on the control desks.

TABLE I

Drive	Motor			Supply
	Type	Rating (hp)	Speed (rpm)	
Pinch roll	D-c	7½	750/850	Generator 1
Feed roll	D-c	30	1000/1100	
Planetary roll	A-c slipring induction	900	495	415-v, 3-phase 50 cycles
Planishing roll	D-c	200	900/1050	Generator 2
Table rolls (2)	D-c	5	1000	
Coiler	D-c	15	285/500	Generator 3
Feed roll screwdown	D-c	10	1200/2400	Constant voltage exciter
Planetary roll screwdown	D-c	5	600/2400	
Planishing roll screwdown	D-c	10	600/2400	

Another generator supplies Ward-Leonard control of power for the planishing rolls and the two table rolls. The planishing roll motor has a field rheostat to enable its speed to be adjusted to the speed of the strip from the planetary rolls, which is determined by the speed of the feed rolls and the roll setting.

A heavy-duty mill-type motor pro-

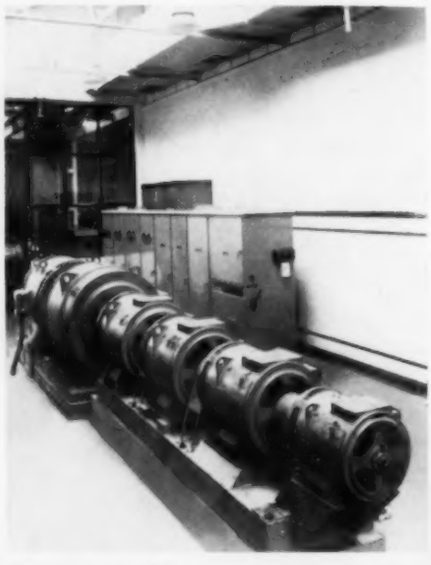


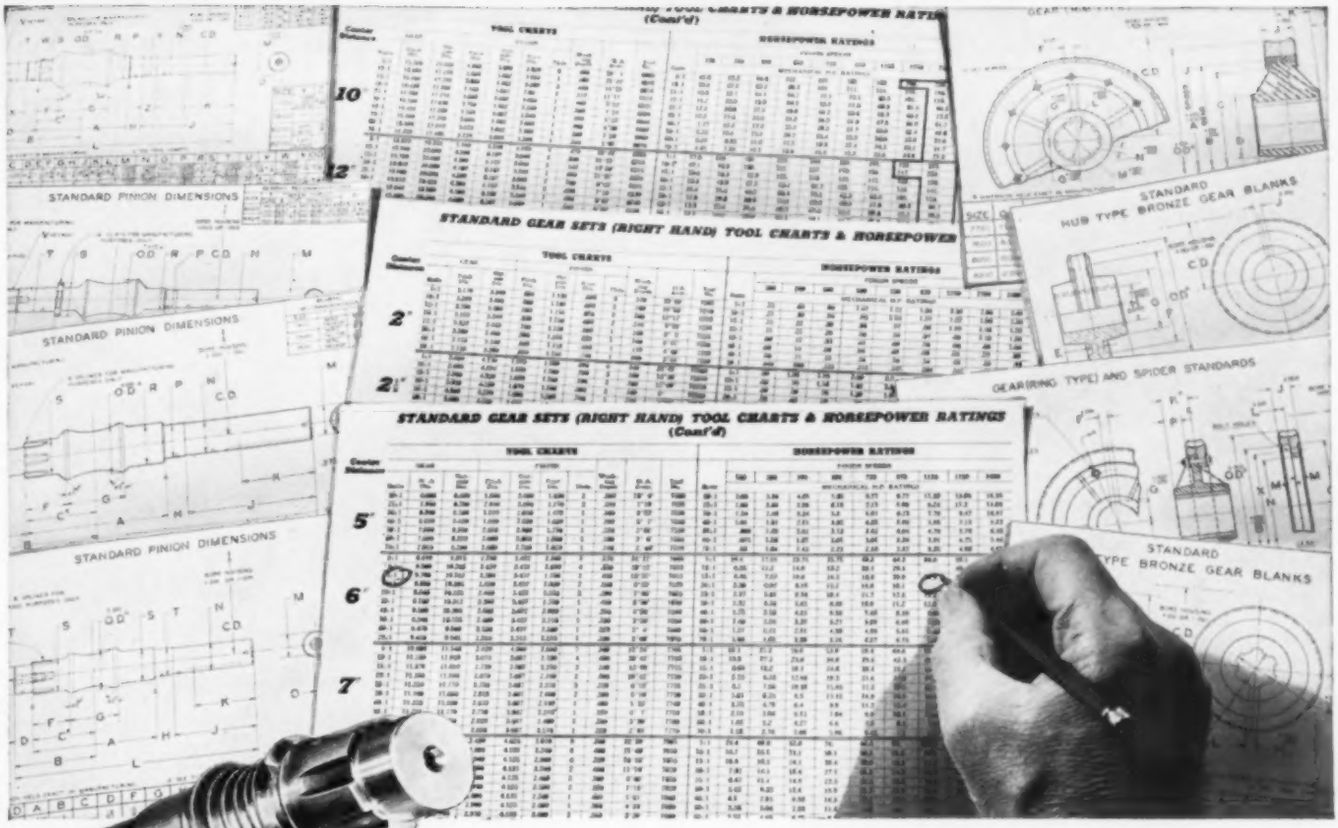
Figure 4 — Motor-generator set supplies the d-c driving motors of the mill. Automatic contactor control of the various d-c drives and a-c auxiliaries is provided by the control board in the background.

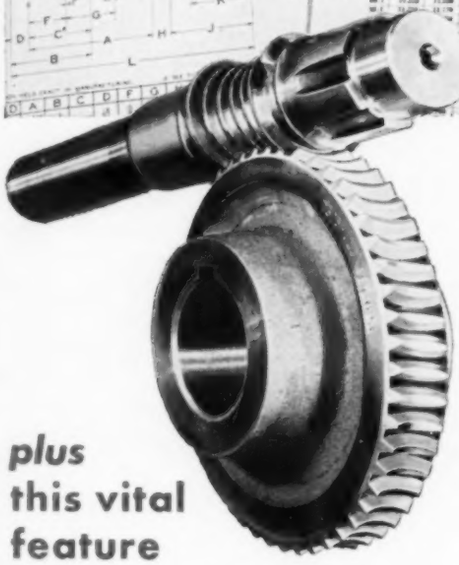
vides rapid acceleration and retardation for the 3-roll coiler, and is supplied by the third generator. The coiler speed is matched to the outgoing speed of the mill by the use of coupled rheostats in the fields of generators 2 and 3. When the end of a strip has passed between the planishing rolls, the coiler motor speed is increased by 75 per cent so that the strip may be completely coiled, the coil ejected, and the coiler rolls returned to mill speed before the leading edge of the next strip reaches the coiler. The two run-out table rolls are adjusted to run at the same speed as the strip from the mill and are not affected by the rapid acceleration of the coiler drive as it coils each strip.

When the mill has been set for a specific program, the speed of all main drive motors may be varied together over a 2 to 1 range by controlling the output of the small exciter that supplies the fields of the three generators.

Screwdown motors are supplied for the feed rolls, planetary rolls, and planishing rolls. The screwdown motors for the feed rolls and planetary rolls have vertical shafts and are skirt

Figure 5 — Control desk for coiler. The mill-type coiler motor can be seen at the rear of the coiler.


STANDARD GEAR SETS (RIGHT HAND) TOOL CHARTS & HORSEPOWER
STANDARD GEAR SETS (RIGHT HAND) TOOL CHARTS & HORSEPOWER RATINGS
(Cont'd)
STANDARD PINION DIMENSIONS
STANDARD
HUB TYPE BRONZE GEAR BLANKS
GEAR (RING TYPE) AND SPIDER STANDARDS



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Lower Cost—due to smaller size of gears and housings, mass production of worm and gear blanks, etc.

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Greater Smoothness—because Cone-Drive gears have more teeth in continuous contact than other forms of gearing.

Wide Range of Sizes—Center distances from 2" to 18" provide horsepower ratings from fractional up to 800 horsepower. Ratios range from 5/1 to 70/1.

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mounted onto bevel gear units that drive the screwdowns through electromagnetic clutches. Electromagnetic brakes are also provided. The planishing screwdown motor has a horizontal shaft and drives through a similar arrangement of bevel gears, clutches and brakes. To ensure accurate adjustment during rolling, and the fast separation of the rolls during an emergency, fast and slow operation of the motors is provided with automatic current-limit acceleration on field weakenings.

Various a-c auxiliary drives were supplied for such items as lubrication and coolant pumps, roll changing gear, and the forced-ventilation fans for the motor-generator room and the mill motors.

The mill is controlled from three desks set respectively in front of the feed rolls, between the planetary and planishing rolls, and in front of the coiler. All the necessary control switches, push-buttons, speed regulators and indicating instruments are provided on these control desks.

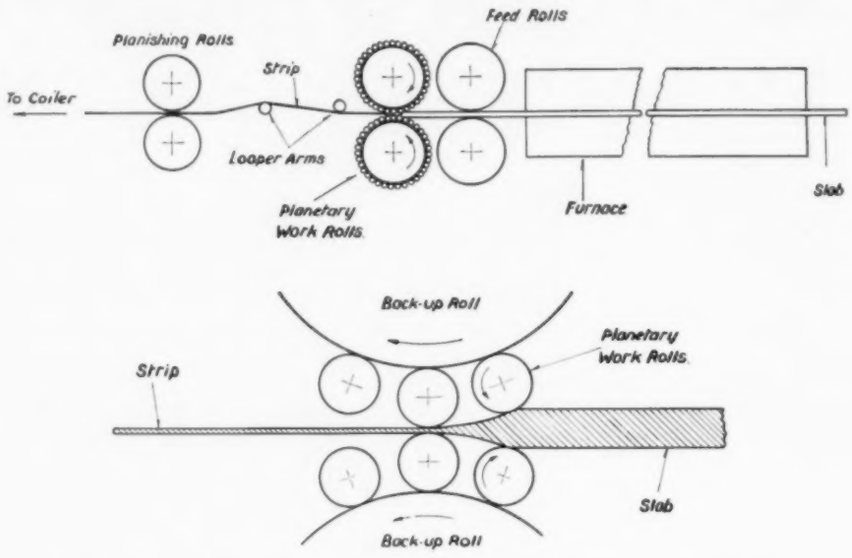

Figure 6 — Sketch shows arrangement of new planetary rolling mill.

NEW COMBINATION ROD MILL WILL DEVELOP HIGH SPEED

By A. F. KENYON
Steel Mill Engineer
Westinghouse Electric Corp.
East Pittsburgh, Pa.

▲THE new combination rod mill now being installed at a northern Ohio plant is designed to operate at higher speed, roll from larger billets and produce heavier rod bundles, and have greater output capacity than any rod mill of its type. The 13,500 hp total capacity of the nine main drive motors also establishes a record high for this type of mill, and the electrical drive equipment incorporates many notable features.

The mill consists of twenty-five two-high roll stands, the first fifteen of which operate as a continuous roughing and intermediate train, with automatic crop and cobble shears between the ninth and tenth stands. After leaving the continuous roughing and intermediate train, the bars may go to a two-stand looping mill and thence to a group of pouring type reels; or alternately, the bars may continue straight ahead to an eight-stand continuous finishing mill and thence to a group of laying reels. The mill is intended to operate continuously with four strands side by side throughout the mill, and the final delivery speed of small rods from the last finishing stand will range to about 6500 fpm. Starting billets normally will be 3½ in. square by 30 ft long to enable finishing 1200-lb rod bundles. The normal range of products will be from No. 5 rod (0.205 in. diameter) to round bar up to 1⅛ in. diameter. There will be eight laying type reels following the continuous finishing mill to coil rod and small bar, and eight pouring type reels following the looping mill to coil heavier bar, also there will be two auxiliary heavy pouring type reels to coil bar up to about 1½ in. diameter which may be finished from stand eleven or thirteen of the intermediate mill.

Table I shows the ratings of the nine main drive motors. The first two stands of the roughing mill are driven by a 600-hp motor "A," stands 3, 4, and 5 are driven together by a 1250-hp motor "B," and stands 6, 7, 8, and 9 are driven together by a 1750-hp motor "C." Flying shears are provided in the mill line following the last roughing mill stand 9, to crop the front end of each bar and assure a good end to enter the following stands, or to cut the bar into short pieces in case of a cobble.

TABLE I

Drive	Stands	Motor hp	Motor rpm
A	1-2	600	300/950
B	3-4-5	1250	225/675
C	6-7-8-9	1750	200/550
D	10-11	1500	225/580
E	12-13	1250	225/620
F	14-15	1250	225/620
G	16a	700	200/680
H	17a	700	250/790
J-K	16 to 23	3 x 1500	690/960

The six intermediate stands are driven in three pairs by a 1500-hp motor "D" and two 1250-hp motors "E" and "F," respectively.

When operating as a looping mill, producing coarse rounds, stands 16a and 17a are driven by two 700-hp motors, "G" and "H" respectively. The drive for the finishing mill consists of a 1500-hp motor "J" coupled to one end of the lay shaft and a

On the Orinoco...

Ore pours from a Link-Belt belt conveyor on the shiploading dock at Puerto Ordaz, Venezuela.

on the Delaware...

Coal at Fairless moves on a belt conveyor equipped with long-lived Link-Belt idlers.

LINK-BELT RESEARCH AND ENGINEERING WORKING FOR INDUSTRY

Link-Belt helps U.S. Steel make history

ON the Orinoco River in Venezuela is the largest iron ore handling system ever built at one time. It carries Cerro Bolivar's iron ore from mine car terminal to ocean-going ships at a rate of up to 6000 long tons per hour. For this giant installation, U. S. Steel's Orinoco Mining Co. selected Link-Belt as the prime contractor. The resulting system provides modern flexible, low-cost handling. For example, one man in the unloading tower controls the ore's movement all the way from stockpiles to ship.

And on the Delaware River is the largest integrated steel mill ever built at one time—U. S. Steel's new Fairless Works. At this "dream mill"—ore, coal and coke are handled on belt conveyors equipped with Link-Belt idlers and speed reducers. Elsewhere throughout the mill, Link-Belt supplied other conveying and power transmission machinery.

Whether your job is large or small, you, too, will find it profitable to rely on Link-Belt. A call to the Link-Belt office near you will place the engineering and manufacturing facilities of this nation-wide organization at your service.

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3000-hp, double-armature motor "K" coupled to the other end of the lay shaft, thus essentially providing a 4500-hp, triple-armature drive.

The three roughing mill motors, "A," "B," and "C," totaling 3600 hp, are connected to bus section I and supplied from a 2920-kw, 700-volt ignitron rectifier. The three intermediate mill motors, "D," "E" and "F," totaling 4000 hp, are connected to bus section II and supplied from form a completely coordinated rectifier unit substation within the motor room. The groups of motor line control panels are installed in the basement below the rectifiers, and the oil-filled rectifier power transformers are installed in the yard outside the motor room.

Each of the three main power supply ignitron rectifiers is controlled by a magnetic amplifier type voltage regulator, to maintain essentially constant voltage on each bus section throughout the load range. Also each of the rectifier power transformers includes a regulating auto-transformer with taps connected to a load tap changer to enable changing the nominal rectifier d-c output voltage from 410 to 700 volts in sixteen equal percentage steps. In addition to enabling operation at reduced voltage, as required by some rolling schedules, the load tap changers also are automatically controlled during normal rolling operation so that the rectifiers operate with minimum phase-back voltage control and hence at the maximum practicable power factor.

With the twenty-three stands of the continuous mill arranged in a continuous line on the minimum practicable centers, and operating essentially without loops at any point, it is essential that the main drive motors have very good steady state speed regulation, also that they have only moderate impact speed drop. To meet these requirements, the motors were designed on a very conservative basis using frames much larger than necessary for normal service. Also each motor is controlled by a magnetic amplifier type speed regulator to obtain the best possible steady state speed regulation and transient impact speed drop performance. The steady state speed regulation of each

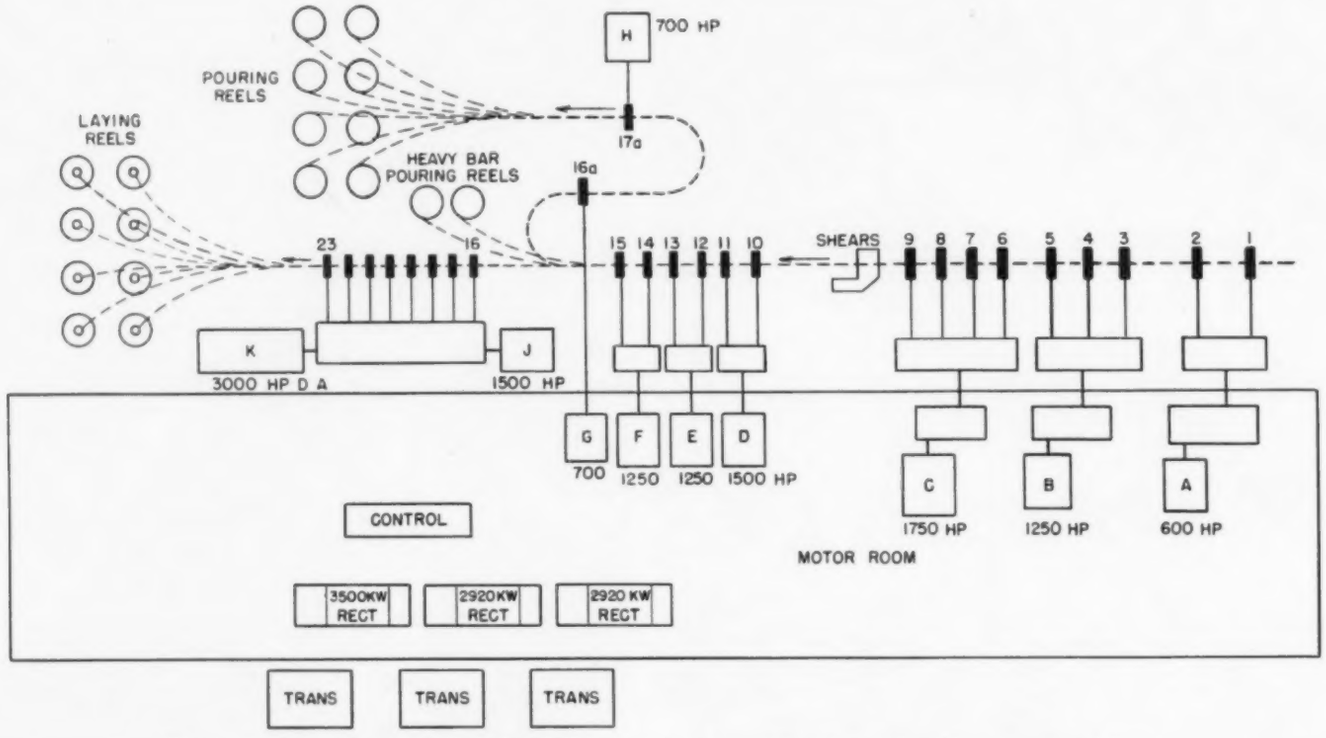

Figure 1 — Schematic arrangement of four-strand combination rod mill and motor drives.

a second 2920-kw rectifier. The two 700-hp looping mill motors, "G" and "H," or alternately, the three 1500-hp motors comprising the 4500-hp continuous finishing mill drive, "J-K," are connected to bus section III and supplied from a 3500-kw rectifier. The three bus sections and their respective supply rectifiers operate independently, and there is no provision for operating the rectifiers in parallel. The motors are started and brought up to speed by rectifier voltage control.

The power supply rectifiers are of the pumped ignitron-tube type, and the twelve ignitron tubes, the vacuum pumping equipment, water-to-water heat exchanger cooling equipment, and excitation equipment are factory assembled in a dead-front metal enclosed cubicle, which lines up with the anode circuit breaker cubicle and the cathode circuit breaker cubicle to

of the motors with their associated magamp speed regulator equipment is expected to be within 0.25 per cent at any speed within the rated speed range. When operating at full field base speed, the regulated impact speed drops are not appreciably lower than the inherent impact speed drops of the motors without any regulating equipment since the mechanical time constants are so short that the regulators cannot respond. However, when operating at weakened field speeds, the time constants are such that the regulators can respond and the regulated impact speed drops are from 30 to 50 per cent lower than the inherent impact speed drops of the motors without regulators. The motor speed regulators thus are quite effective in improving the transient impact speed drop characteristics of the drive motors as well as providing the best possible steady state speed regulation.

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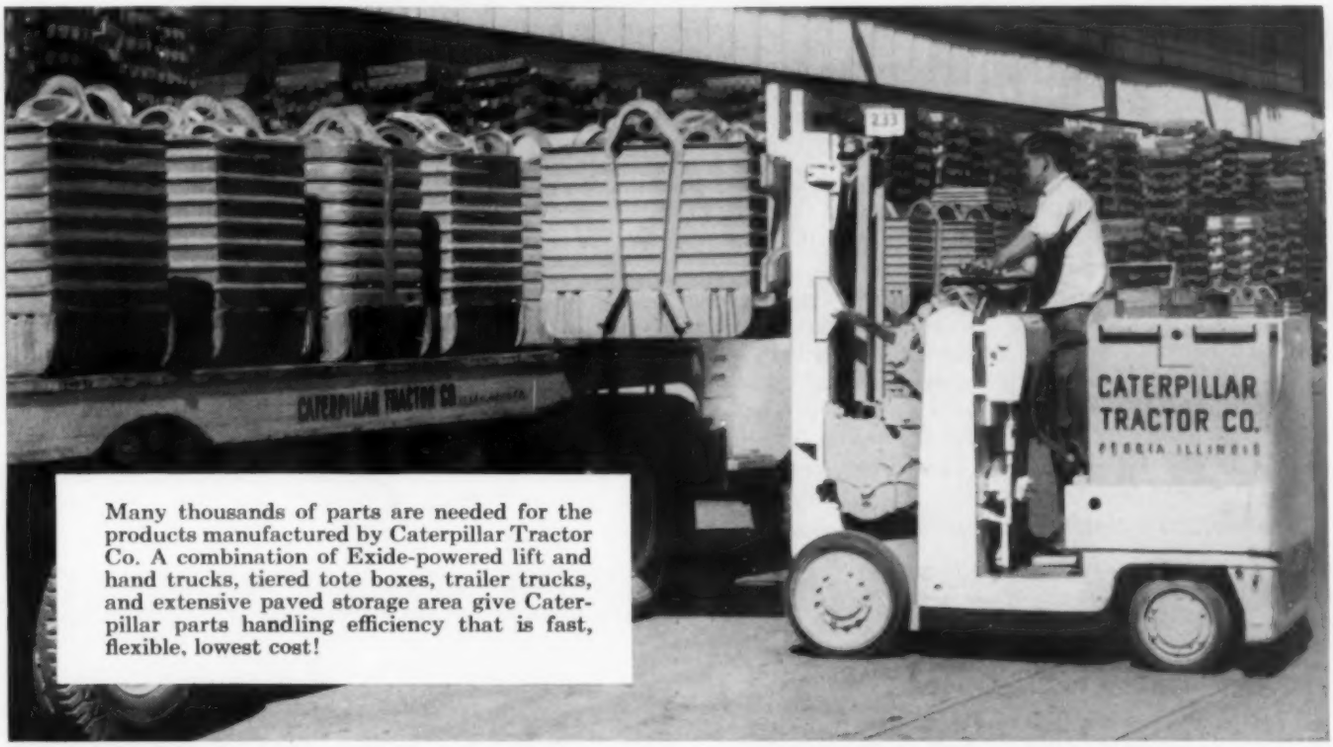
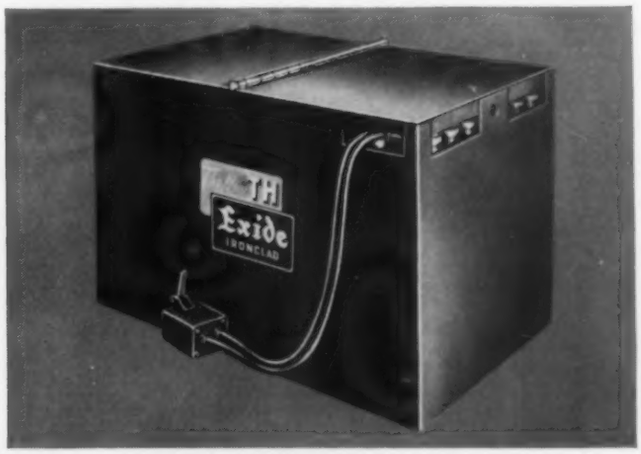


Many thousands of parts are needed for the products manufactured by Caterpillar Tractor Co. A combination of Exide-powered lift and hand trucks, tiered tote boxes, trailer trucks, and extensive paved storage area give Caterpillar parts handling efficiency that is fast, flexible, lowest cost!

YOU GET split-second handling, uniform performance throughout each shift when electric trucks are powered by dependable Exide-Ironclads. Whether the load is light or heavy, Exide-Ironclads deliver power instantly, insuring smooth, rapid handling of materials. Your trucks handle as much pay load during the last hour as during the first . . . with no unscheduled down time. Lower costs for operation, maintenance and depreciation make Exide-Ironclads your best power buy—AT ANY PRICE!

THE POSITIVE PLATES are the heart of any battery. Only Exide uses a slotted tube construction. By use of tubes, more active material is exposed to the electrolyte, providing *greater power*. Also, more active material is retained, *giving longer working life.*



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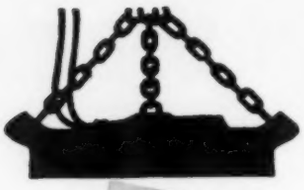

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OHIO BASKET MAGNETS. 55 & 65" 4-coil, & 65" 6-coil. For extra heavy-duty service. No weight carried by bolts. Also capsule-coil over 45".

In slag reclamation or rough service—or any use where magnets are subjected to hard knocks—you need the extra heavy construction and greater lifting power of Ohio Magnets.

This super-strong Ohio Basket Magnet has an outer ring with integrally cast fenders that project beyond magnet diameter to ward off and protect against damaging blows. Extra heavy top plate is held in place with strong nickel-steel bolts.

For extra magnet life, extra magnet value—specify Ohio Magnets. Remember, Ohio Magnets lift larger loads longer—*especially with Ohio Magnet Controllers.*

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CHESTER BLAND
President

NEWPORT STEEL

Completes Reversing Hot Mill

▲NEWPORT Steel Corp. completed recently a new reversing hot strip mill, this is part of the company's $9,000,000 expansion and modernization program.

Another new mill now under construction for cold rolling steel, a major item in Newport's program for a further diversification of end products being forwarded since the company's acquisition by Merritt-Chapman & Scott Corp. early this year, is expected to be in operation by early 1955.

Other improvements recently completed by Newport include extensions to its pipe mill, culvert coating equipment and new pipe and gutter machines.

Newport Steel is one of the few mills in the United States where strip is rolled directly from ingot into finished coil in one straight line operation. The new reversing hot mill now enables the company to produce lighter and wider coils and sheets in gages of maximum uniformity to exact specifications.

Ingots from the electric furnace department are charged into six circular soaking pits. The ingots are then rolled through a vertical edger and slabbing mill, where they are reduced into flat plates 5/8-in. thick and approximately 135 feet long.

The ends are cropped and, still in plate form, the steel moves on rollers into a roller hearth furnace. From there it passes through a scale breaker, with descaling sprays, to remove surface scale formed during the initial rolling. It is now ready to enter the newly installed four-high hot reversing mill, where it is rolled into coils from 1/4 to 1/16-in. thick, up to 48-in. wide and approximately 1350 feet long. This is the critical phase of the rolling operation. As it moves back and forth through the rolls, it is alternately coiled in hot coiler furnaces located on either side of the mill.

The new mill is much heavier than the one it replaces, providing proportionately greater strength and precision control, important in achieving maximum uniformity of gage. Its installation now enables Newport to supply its customers with more uniform hot rolled and hot rolled pickled coils and sheets in lighter gages than before. The new mill can produce coils up to 48-in. wide in a full range of steel analyses.

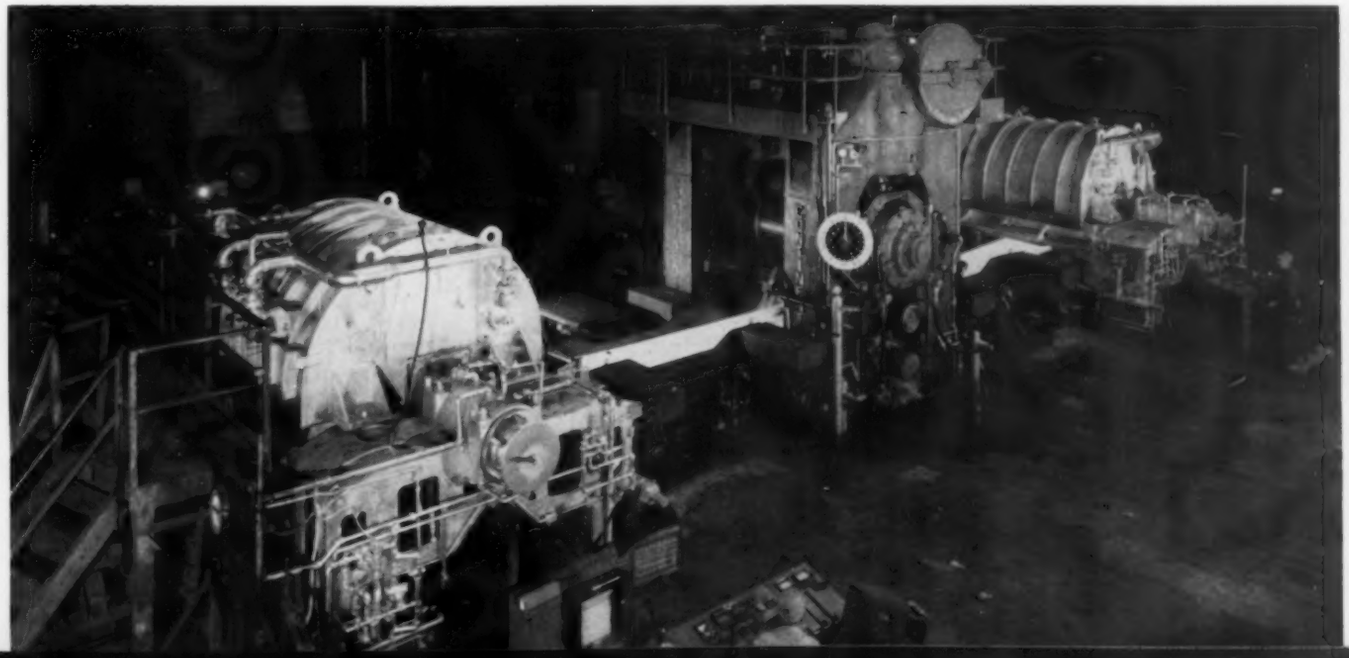
Manufactured for Newport by the Continental Foundry & Machine Corp., the mill size is 26 by 49 by 66-in. The two work rolls are 26-in. in diameter, and the two back-up rolls are 49-in. in diameter. All rolls are 66-in. in body length and are housed in steel castings weighing more than 90 tons each.

The mill is powered by a 4000-hp, d-c reversing motor, with direct drive through a pinion stand. It is equipped with hydraulic roll balance, Timken anti-friction work roll bearings and Morgoil back-up roll bearings.

The new mill was installed in the exceptionally short time of 25 days, with work scheduled so as to avoid any interruption of plant operations. Dismantling of the old mill was started July 6th. All new equipment was installed and started on test runs by July 31. The major part of the installation period coincided with scheduled plant vacations.

All installation work was performed by Newport personnel, under the direction of A. P. Miller, vice president in charge of operations.

Figure 1 — New reversing hot strip mill installed at Newport Steel Corp., Newport, is driven by a 4000-hp, d-c, reversing motor.



Here's how HOUGHTON

Many things to many men . . . that's the Houghton picture on steel mill applications.

You may know Houghton for its Hydraulic Department, where moulded packings have been made for two generations, and used by practically every steel producer. Current types include leather, synthetic rubber and the new rubber-impregnated leather (VIM 1243) that is taking industry by storm.

Or, you may know Houghton as a specialty lubricant house, fortifying petroleum oils and greases to do vastly improved lubrication jobs . . . open gears, hot spots, lube additives for water systems or for fuel oils . . . scores of items for hundreds of specialized applications.

And it is possible that your knowledge of Houghton has been based largely on its metal-working products: rust preventives, heat treating and quenching oils, cutting oils and bases, pickling inhibitors, hot top insulating materials, hot forging agents.

But no matter how you classify this 89-year-young Company, it is certain that Houghton products can be of aid. Behind them is a definite plus value—a field and laboratory service unequalled in our type of industry—also helpful, authoritative publications and manuals highly regarded by metal men.

Get to know Houghton better through the widely known "Houghton Line", published since 1907. If you do not now receive it, write E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Penna.

serves the STEEL INDUSTRY

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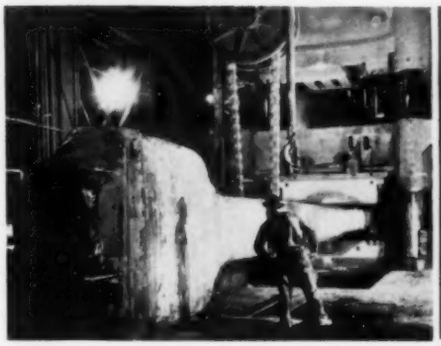
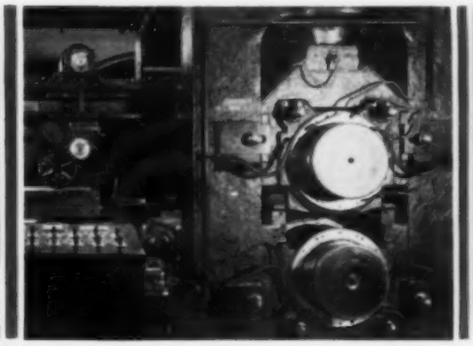
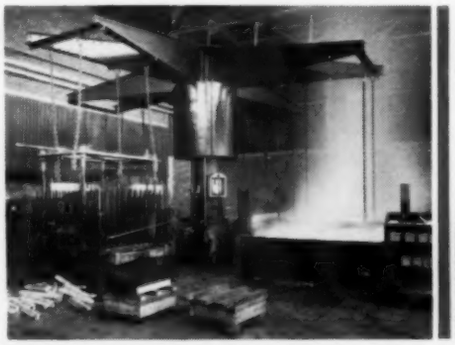


Houghton hydraulic fluids and lubricant additives for water systems, plus Houghton packings, add to useful press life.

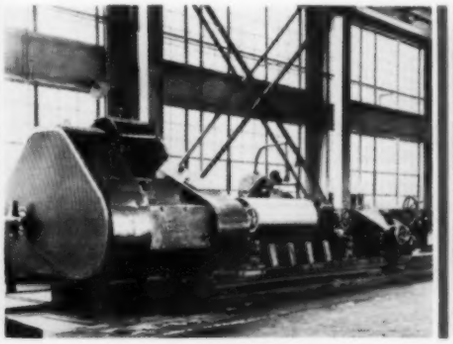


All through the mill Houghton leather and synthetic rubber packings serve long and ably . . . such as on roll jacks, above.

Hydraulic applications, such as dolomite charger above, call for Houghto-Safe nonflammable hydraulic fluid in steel mill hot spots.



Improving Pickling Acitrol pickling inhibitors help conserve both steel and acid. Houghton surface active agents, added to rinse bath, assure quicker, cleaner rinsing.



Precision Roll Grinding Houghto-Grind 50, additive for water used as grinding coolant, assures freedom from early rusting. Rust Veto coatings protect rolls in storage.

Tomorrow's Lubricants, Today Fortified lubricants specifically built for steel mill use will withstand extreme pressures, protect gear sets, function well in pressure systems. Write for special booklet.

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HOSE CHECK LIST

By J. A. MULLOR, Thermoid Co.

▲ A user of rubber hose can get longer life and more satisfactory performance by applying the following check list to each hose in his plant, construction job, machine, mine, or quarry and to each hose specified for purchase in the future.

1. Material carried—If the hose carries any kind of petroleum product, the tube should be compounded to resist attack by oil, grease or gasoline, for example. There are several standard hose types available designed for this type of service. Paint and insecticide spray hose must be built to resist the various solvents incorporated in the new paints and insecticides. Many kinds of dilute acids can be carried by rubber hose, but the user should make sure that the hose he is using is designed for the acid. Solids carried either dry or in a slurry require that the tube of the hose be composed of pure gum rubber type to resist abrasion. If the solution contains acid petroleum products or other solvents, various additives must be compounded into tube rubber to resist them.

2. Hose size—Is the inside diameter adequate to carry the volume of material required? Too small a hose means excessive pressures will be developed or that less than the required amount of material will be carried. Too large a hose means higher cost than necessary, poor, irregular flow.

3. *Pressure*—Is the hose designed to take the pressures imposed? Are you using higher pressures than you need to, which results in excessive hose costs? Is the pressure constant or is it pulsating? Pulsating pressures should be avoided. Is the pressure positive or negative, under vacuum or suction? Suction hose requires a spiral or ring type reinforcement in the carcass to prevent hose collapse under suction.

4. High and low temperatures must be watched—High temperature applications require special rubber compounds and asbestos or other heat resisting material in the carcass. Running both hot and cold material through a hose should be avoided. Constant heating and cooling may cause cracks to develop in the rubber tube and cover permitting direct attack on the carcass. As far as possible, a hot steam hose should be drained after use to prevent pocketing of condensate which becomes absorbed by the hot tube stock leading to eventual blistering if continually repeated.

5. Solids—If solids are carried in the hose, what are their relative size and abrasiveness? Abrasive material in an aqueous solution requires a pure gum rubber tube. If the solids are carried in a corrosive liquid, the tube must be compounded to resist attack by this liquid and a compromise hose results.

6. *Know and observe bending radius limits of your hose*—The most common fault is suspending hose off the floor or ground by metal projections with too little bearing area such as nails. Avoid the use of nails because of their small diameter. In addition to unnecessarily bending the hose at these points, the cross section of the hose is reduced. Resistance to flow is increased, unnecessary turbulence is set up. Use saddle type supports with adequate bearing contact with the hose.

Put supports close enough together so that hose weight is evenly distributed, so that large hanging loops do not affect flow of material, so that hose is not strained by supporting too much of its own weight.

The bending radius of most industrial hose is approximately one foot for every inch of inside diameter of the hose.

7. Length—Obviously a hose system should be designed to avoid stretching. This weakens the hose and puts unnecessary strain on the coupling. Too much length runs up the hose cost and permits snagging and kinking.

8. Twisting — Avoid twisting or torsional strains, especially in short hose lengths. Twisting will tend to separate the reinforcement from the tube and cover. It may even seriously disarrange the reinforcement. In a wrapped hose in which the reinforcement is cut diagonally to the warp of the fabric, twisting may weaken the structure.

9. Cycle of operation—Many hose do the same job at the same pressures and temperatures twenty-four hours a day without valves being shut off and on. Other hose may be subjected to an extremely vigorous cycle with many sudden interruptions in flow, long periods of idleness, wide temperature variations and even drastic changes in environment. Consider, for example, deep sea operations. For several hours a day, the hose is immersed in cold salt water. Then, it is brought up on deck and stored in hot, strong sunlight. This represents a challenge to the hose designer, but it also requires consideration from the user who can obtain longer hose life with standard hose by reducing the severity of some parts of the operation.

In many types of hose service, the position of the hose is changed frequently. More often than not, it is dragged from place to place. An abrasive resistant cover is needed. In addition, if the moves are very frequent, a quick-disconnect type of coupling will save time.

When hose is not to be used for a long time, it should be drained, wiped clean of oil or grease and stored in loose coils, preferably flat on the floor, inside, out of the sun.

10. Couplings — Are the correct types of couplings being used? Are they correctly installed? Are they properly maintained, tightened periodically, checked for leaks? If service requires frequent disconnecting, are the couplings designed for easy, fast disconnecting?

11. Protection against accidental damage — In hazardous areas, are hose protected against damage from falling rocks, from heavy vehicles at hose crossings? Is the hose kept out of strong sunlight as far as possible? Are you protected against work stoppages by accidental hose failure by an adequate stock of spare hose and couplings?

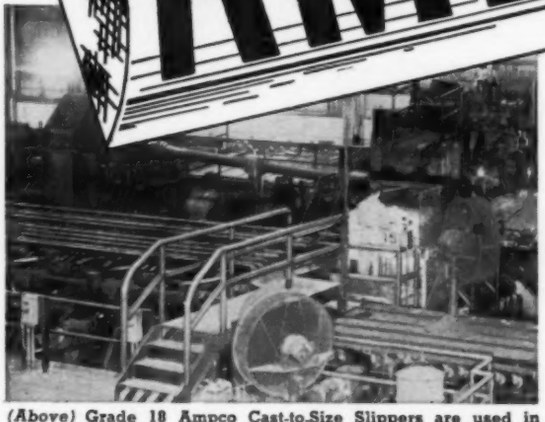
12. Working conditions—In many cases the ambient temperature and pressure must be considered. The temperature of the room in which the hose works must be added to the temperature of the material being carried.

At the Lorain Works of National Tube Company

Ampco Metal is specified for a variety of jobs where its high resistance to pressure, shock, and fatigue pays off in long-wearing economies. Shown here is one of 8 Ampco Grade 18 guides which take the lateral pressure of the top roll on the No. 4 Blooming Mill illustrated below.

AMPCO METAL

Ampco-Cast-to-Size Slippers are furnished +1/32"—0" or —1/32"+0" tolerance with oil grooves "cast-in" to requirements. Accurate surface finishes eliminate necessity for machining.



(Above) Grade 18 Ampco Cast-to-Size Slippers are used in the Universal Joints of this seamless piercing mill at the Lorain Works.

(Below) in the same piercing mill Ampco Grade 18 internal and external nuts are used for height adjustment controls.

stands up longer in steel mill service...

Yes, Ampco Metal is a "tough customer." It has to be—to take the terrific beating of steel mill pressure loads, shock, and fatigue. You can't beat it for rugged wear-resistance. That's why more and more mills (like the Lorain Works) specify Ampco Metal to cut maintenance service, downtime, replacement costs, and production losses.

Protect your production schedules. Insist on wear-resistant Ampco metal (aluminum bronze) for wear plates, slippers, screwdown nuts, flash welder dies, pickling equipment — and other proven spots where Ampco's extra toughness pays off in reduced costs.

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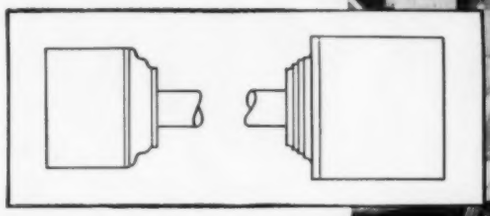
● The cost of Ajax Dihedral Couplings is insignificant compared to the cost of downtime in any department of any mill! America's foremost designers of heavy mill equipment are welcoming the ability of Ajax Dihedral Couplings to handle heavy horsepower, high speeds, and shock loads under rolling mill conditions.

Long life and trouble-free operation without the usual maintenance on spindle drives between pinion stands and rolls.

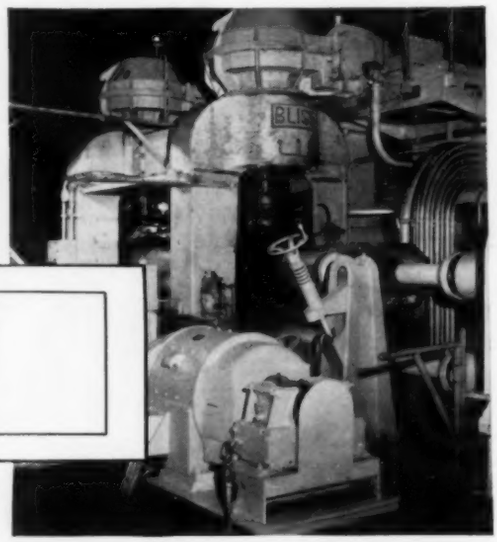
When Design Engineers specify...

AJAX DIHEDRAL FLEXIBLE COUPLINGS

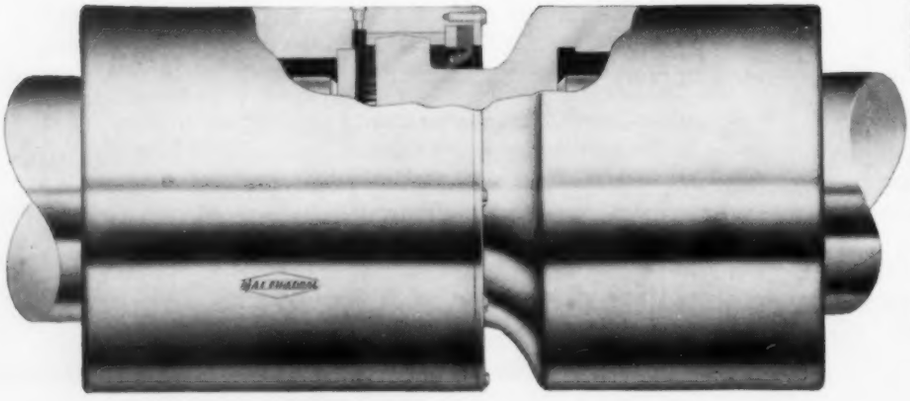
they must be good



Cut-away view of Ajax Spindle Shaft Dihedral Coupling as used between pinion stands and rolls.



Showing two sets of Ajax Spindle Shaft Dihedral Couplings installed on Bliss 32" x 80" Two-High Temper Pass Mill in operation at the Fairless Plant of the U. S. Steel Corp., Morrisville, Pa.



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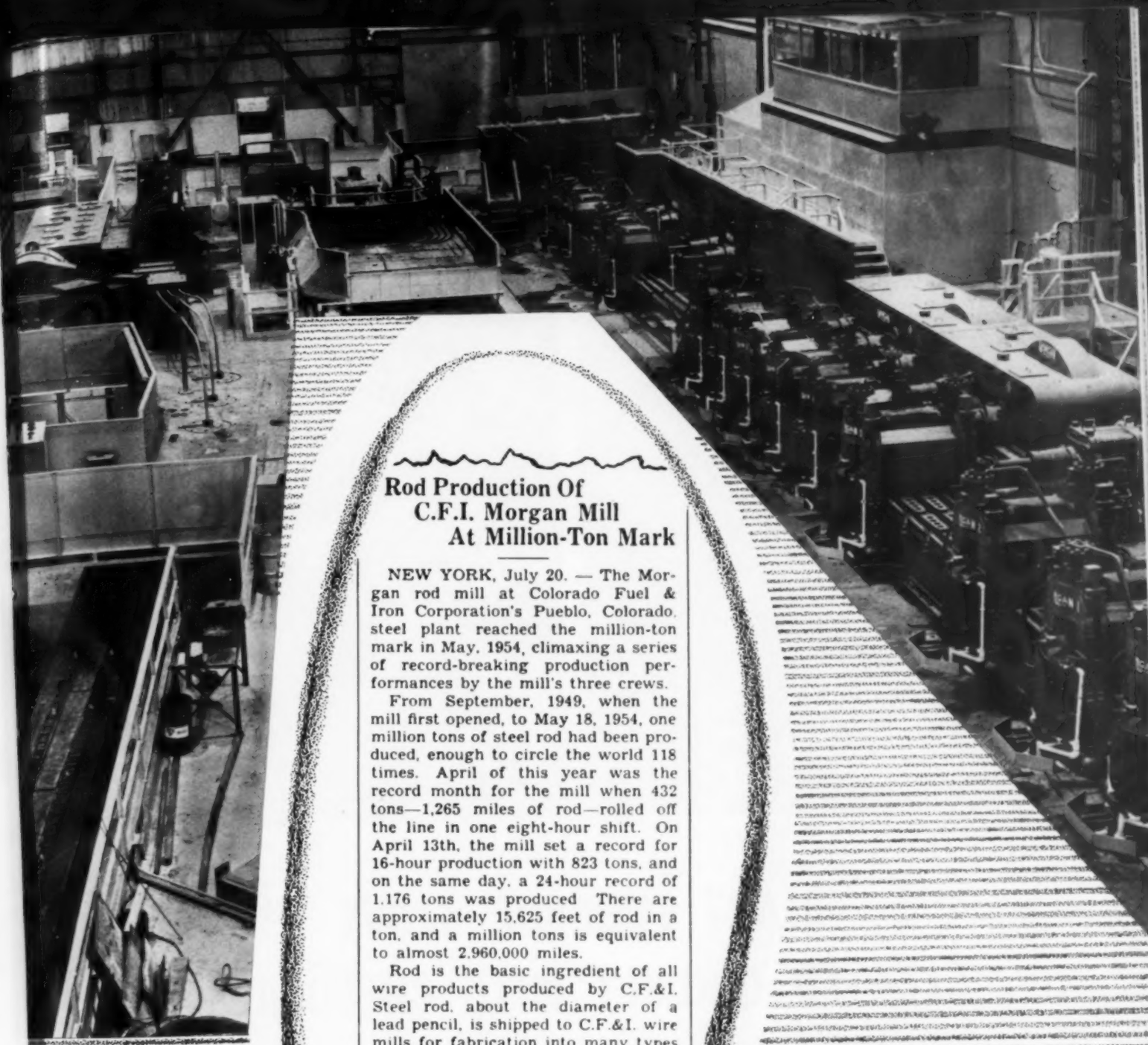
Representatives in Principal Cities

WESTFIELD, N. Y.



Rod Production Of C.F.I. Morgan Mill At Million-Ton Mark

NEW YORK, July 20. — The Morgan rod mill at Colorado Fuel & Iron Corporation's Pueblo, Colorado, steel plant reached the million-ton mark in May, 1954, climaxing a series of record-breaking production performances by the mill's three crews.

From September, 1949, when the mill first opened, to May 18, 1954, one million tons of steel rod had been produced, enough to circle the world 118 times. April of this year was the record month for the mill when 432 tons—1,265 miles of rod—rolled off the line in one eight-hour shift. On April 13th, the mill set a record for 16-hour production with 823 tons, and on the same day, a 24-hour record of 1,176 tons was produced. There are approximately 15,625 feet of rod in a ton, and a million tons is equivalent to almost 2,960,000 miles.

Rod is the basic ingredient of all wire products produced by C.F.&I. Steel rod, about the diameter of a lead pencil, is shipped to C.F.&I. wire mills for fabrication into many types of wire products, including nails, fencing, staples, screen, and wire cloth.

From
AMERICAN METAL MARKET
Issue of: JULY 21 1954

Why Speak of Records, when Records Speak for themselves

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Regenerative Furnace Control - Ejectors - Gas Producers

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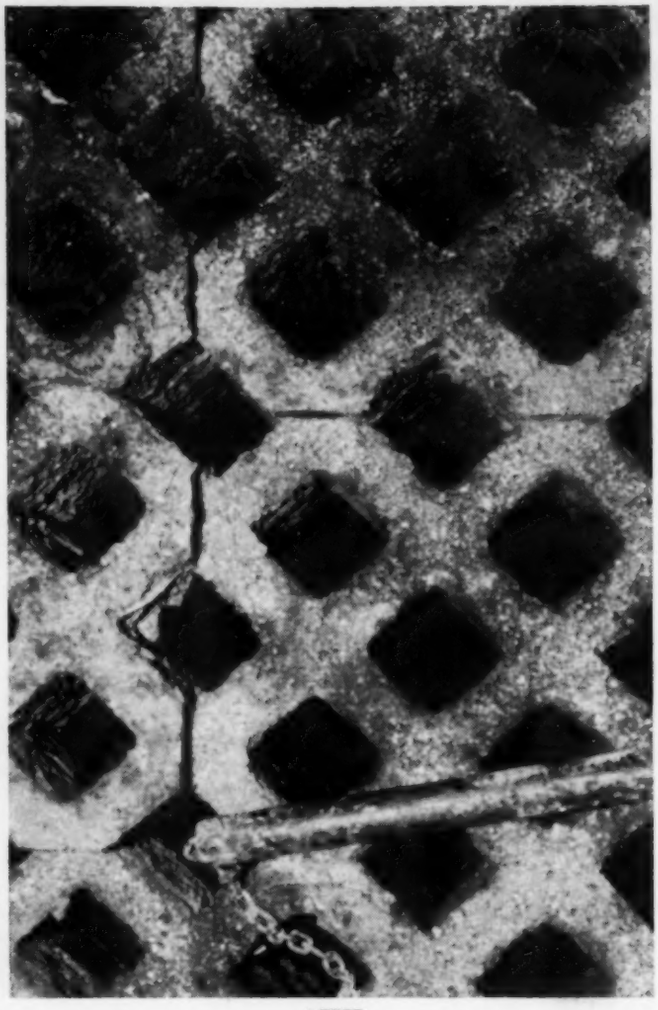
BEFORE



AFTER

BLAST FURNACE STOVE CLEANED QUICKLY WITH CHEMICALS

Total outage was only 10 days on 3400-checker unit

The desired dome temperature of 2000° F. could not be obtained on this blast furnace stove because of plugged checkers. Maximum temperature reached was 1700° F. This reading dropped below 1100° F. within an hour after the stove was put on furnace. Cleaning was imperative.

Dowell engineers applied chemical solvents using high-pressure jet lances. All 3400 of the checker passages were opened and restored to full effectiveness in just 50 hours. Total outage was only 10 days—about half the time normally required when other methods of cleaning were used.

Checkers of even the smallest size—square or round, with ball or star inserts—have been cleaned quickly and effectively without breaking, using Dowell chemical solvents. The Dowell method is designed to clean corners and other surfaces inaccessible to mechanical means.

For complete information on chemical cleaning of blast furnace gas cycle equipment, boilers, towers, heat exchangers, lines, water wells—call the nearest of over 130 Dowell offices. Or write directly to DOWELL INCORPORATED, Tulsa 1, Oklahoma, Dept. I-29.

DOWELL SERVICE

chemical cleaning services for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

August 2

▲ The AISI reports operating rate of the steel industry for the week starting August 2 is scheduled at 64.8 per cent of capacity. This is equivalent to 1,544,000 tons compared with 1,532,000 tons one week ago and 2,119,000 tons one year ago. Index of production for the week is 96.1.

▲ A strike of 2200 employees at eight plants of the Reynolds Metals Co. was called by the United Steelworkers.

▲ Installment purchases of automobiles, home appliances, etc., had increased by $178,000,000 in June according to the Federal Reserve Board.

August 3

▲ U. S. Steel Corp. will idle 15 of its 59 ships of the Pittsburgh Steamship Fleet soon after September 1.

August 4

▲ Hilton Hotels Corp. signed a contract to acquire Hotels Statler Co. This would make Hilton the largest chain of first class hotels in the world. If the transaction is carried out, the total price of $76,000,000 will be paid by Hilton.

▲ According to the AAR, $59,000,000 was netted by major railroads in June which is 26 per cent below June one year ago.

▲ A ½¢ increase per lb in the price of 99 per cent minimum average aluminum pig and an increase of 7/10¢ per lb in the price for 99 per cent plus ingot, was announced by ALCOA, bringing prices up to 20.5 and 22.2 respectively.

August 5

▲ Steel scrap advanced $1 a ton in Pittsburgh and Cleveland following a month of slow demand.

▲ The Secretary of Treasury asked the Senate Finance Committee for a $10,000,000,000 boost in the present $275,000,000,000 ceiling on the public debt.

August 6

▲ Manila expects to complete a $5,000,000 steel plant to produce steel bars and construction materials by the end of 1954. Equipment is to come from Japan.

▲ The Senate Finance Committee approved the Treasury's long fight for an increase on the public dept by granting a $6,000,000,000 raise on its $275,000,000,000 ceiling until June 30, 1955.

▲ Commerce and Labor Dept. reports a record high of $3,500,000,000 in July on construction outlays up 5 per cent over June.

▲ The S. S. Hawaiian steamed in with 20,000 tons of iron ore the first from the Labrador-Quebec mining development which is destined for blast furnaces in Pennsylvania, Ohio and Virginia.

August 7

▲ Shipments of finished steel products in June were 5,887,488 net tons compared with 5,423,168 tons in May, the AISI reports.

August 9

▲ The AISI reports a rise in employment in the entire iron and steel industry in this country to an estimated total of 608,900 in June from 606,400 in May, and an estimated average of 621,000 for the first half year. Average hourly rate in June set a new high of $2,315 for an average 36.0 hours per week. Total payroll in June was $236,406,000.

▲ The AISI reports operating rate of the steel industry for the week starting August 9 is scheduled at 63.7 per cent of capacity. This is equivalent to 1,519,000 tons compared with 1,527,000 tons one week ago and 2,146,000 tons one year ago. Index of production for the week is 94.6.

▲ The ICC rules that railroad's may give door-to-door piggyback service in its first formal set of rules governing transporting highway trailers on flat cars.

August 10

▲ U. S. Steel Export Co. will cut export base prices as high as 20¢ per 100 lb, concurrent with the lower freight rates on steel for export from North Atlantic ports.

▲ The Aluminum Assoc. reported total primary production of aluminum in June amounted to 241,360,488 lb as compared with 250,287,697 in May, and 208,303,690 lb in June one year ago.

August 11

▲ According to the AISI, exports of finished steel products in 1953 totaled 3,100,000 tons, 26 per cent below one year ago.

▲ The Commerce Dept. reported wholesalers' volume reached a new high of $95,900,000,000 in 1953, 2 per cent above the 1952 high.

August 12

▲ The F. W. Dodge Corp. reported a July total of $1,836,935,000 for contracts in the 37 states east of the Rockies, up 2 per cent over July 1953 and 6 per cent above June 1954.

August 13

▲ Studebaker union members of the CIO United Auto Workers voted 5264 to 622 to accept a 14 per cent wage cut to enable the company to make more competitive autos.

▲ Follansbee Steel Corp. has agreed to sell all its assets to a New York financial group headed by Frederick W. Richmond for $9,000,000. The remaining corporate shell of Follansbee will merge into two building materials and chemical firms controlled by Clint W. Murchison, Texas oilman.

▲ The SEC stated that corporations sold $2,500,000,000 worth of new stocks and bonds in the second quarter of 1954, 8 per cent less than in 1953.

▲ Birdsboro Steel Foundry and Machine Co. will schedule a meeting to vote on the sale of substantially all its assets to Frederick W. Richmond of New York for $3,970,000 or around $20 a share of outstanding stock.

August 16

▲ According to the Commerce Dept., gross national product held an annual rate of $356,000,000,000 the second quarter of 1954, up $200,000,000 from the first 1954 quarter and 4 per cent below the second quarter in 1953.

▲ The AISI reports operating rate of the steel industry for the week starting August 16 is scheduled at 62.1 per cent of capacity. This is equivalent to 1,481,000 tons compared with 1,525,000 tons one week ago, and 2,162,000 tons one year ago. Index of production for the week is 92.2.

August 17

▲ The new tax revision measure of the Internal Revenue Code signed by President Eisenhower gives taxpayers $1,400,000,000 of relief this year.

▲ The House passed and sent to the White House a $6,000,000,000 temporary boost in the public debt

limit. The Treasury Secretary had asked for a $10,000,000,000 additional allowance.

▲ The Aluminum Assoc. reported primary aluminum production in the U. S. totaled 252,323,794 lb in July 1954 compared with 241,516,343 (revised) lb in June, the previous month, and 218,570,626 lb in July of 1953.

▲ Stockholders of the Packard Motor Car Co. and the Studebaker Corp. voted and approved the proposal to combine their businesses in the Studebaker-Packard Corp. The combined corporation now holds assets of around $251,400,000; working capital of around $85,700,000 and a net worth of approximately $178,736,000.

August 18

▲ National Steel Corp. chairman, E. T. Weir, states that steel requirements give no indication of improvement in September. Operating rate for the last quarter of 1954 is expected to rise to around 70 per cent.

▲ Bethlehem Steel's considered merger with Youngstown Sheet and Tube Co. is said to be a violation of the anti-merger act by Rep. Celler of New York. He requested the Justice Dept. to block any consolidation of these two firms which would have a bad effect on steel competition.

▲ The Office of Defense Mobilization proposed a titanium expansion goal to process 37,500 tons of ingots a year by 1956.

▲ Deliveries of new domestic freight cars in July 1954 totaled 1801 compared with 2650 in June and 6370 in July 1953, the ARCI announced today. Orders in July totaled 883 leaving a backlog as of August 1 of 12,889.

▲ General Electric agreed with CIO International Union of Electrical Workers on a new contract giving employees a wage boost averaging about 5¢ an hr.

▲ The Army and Atomic Energy Commission invited proposals from 33 U. S. companies to design and construct an atomic power reactor.

August 23

▲ European steel production is increasing and despite a slow first half, the rising second half will bring the total 1954 steel production equal to that of 1953.

▲ The AISI reports operating rate of the steel industry for the week starting August 23 is scheduled at 62.7 per cent of capacity. This is equivalent to 1,496,000 tons compared with 1,474,000 tons one week ago and 2,106,000 tons one year ago. Index of production for the week is 93.1

▲ The president ordered sharp hikes in Federal purchases of lead and zinc as a substitute for higher import duties. Under these new goals, U. S. buying may reach 200,000 tons of lead and 300,000 tons of zinc for the fiscal year ending June 30, 1955.

August 24

▲ Class I railroads netted $224,000,000 for the first half of 1954, down 46 per cent from the $417,000,000 of the corresponding period in 1953.

▲ Kaiser Aluminum and Chemical Co. has purchased 2500 acres of land near Ravenswood, W. Va. for construction of an aluminum sheet and foil rolling mill. The work is scheduled to start January 1.

August 25

▲ A conciliation board in Canada recommended a general wage increase of 5¢ an hr for nearly 7000 workers at the Steel Co. of Canada, Ltd., Hamilton, Ontario plant.

▲ July bookings of fabricated structural steel amounted to 259,342 tons, according to the AISC, an increase of 18 per cent over June 1954 and approximately 39,000 tons greater than the corresponding month of last year. Shipments in July totaled 243,824 tons. Backlog of work ahead as of July 31 stands at 1,429,061 tons.

August 26

▲ Lead prices were increased ¼¢ in New York to 14¼¢ per lb, and in East St. Louis to 14.05¢ per lb.

▲ Machine tool orders received in July fell to its lowest level this year said the National Machine Tool Builders Association. Orders totaled only $36,500,000 as compared with the $55,000,000 in June.

August 27

▲ A report of the AAR stated that freight car loadings of 678,624 cars last week dropped 17 per cent or 138,822 cars, below the corresponding week in 1953 and were 1 per cent, or 6653 cars, below the preceding week.

▲ Shareholders of Birdsboro Steel Foundry and Machine Co. approved the sale of all the assets of their company to Frederick W. Richmond of New York for $3,970,000 or about $20 a share of outstanding stock. Firm will continue its business.

August 30

▲ U. S. Steel Corp. announced new mill price increase for tin mill products of 10¢ per base box.

▲ Bethlehem Steel Co. was asked by Assistant Attorney General Barnes to furnish information on its proposal to merge with Youngstown Sheet and Tube Co.

▲ Shipbuilding firms expect a low year in 1955 despite the Government's new $401,000,000 construction and repair program.

▲ Manufacturers' sales in July reached a total of $22,400,000,000 which is $2,300,000,000 below the corresponding month in 1953, the Commerce Dept. reported.

▲ The F. W. Richmond group of New York agreed to buy the assets of Hydraulic Press Manufacturing Co. for $4,300,000.

▲ A certificate of necessity to construct a $13,000,000 plant to melt and process titanium has been granted Rem-Cru Titanium, Inc. This expansion will increase the firm's capacity from its present 2500 tons a year to 11,150 tons.

▲ The AISI reports operating rate of the steel industry for the week starting August 30 is scheduled at 64.8 per cent of capacity. This is equivalent to 1,544,000 tons compared with 1,515,000 tons one week ago and 2,140,000 tons one year ago. Index of production for the week is 96.1.

▲ American Smelting Co. granted its Mine-Mill workers a 7½¢ hourly wage increase. This affects 6000 employees at 12 plants.

▲ A 6½¢ hourly wage increase was granted CIO Rubber workers by U. S. Rubber Co. This affects over 32,000 employees in 19 plants.

▲ U. S. commercial exports in July were valued at $1,022,000,000, an increase of $63,000,000 over July of 1953.

▲ The Commerce Dept. reported that personal income has remained stable in July from the previous month with a yearly rate of $286,500,000,000.

▲ Youngstown Sheet & Tube Co. announced it planned to curtail some operations in the latter part of September for mill repairs.

▲ On sales of $128,491,032, Kaiser Steel Corp. had net earnings of $7,926,666 for the fiscal year ending June 30, 1954. Sales were down 4.5 per cent from the previous year.

25-Ton, 72-ft. span Bedford Crane over the mold yard in Detroit Steel Corporation's new mill at New Boston (Portsmouth), Ohio.

Bedford Cranes continue to gain favor with steelmakers

Repeat orders tell the story: in steel mills, power plants, throughout heavy industry . . . wherever superior performance is demanded . . . men who know equipment are re-ordering Bedford Cranes.

For these men know from experience that Bedford Cranes — backed by over a half-century of specialized crane building and utilization experience — will deliver consistent top-notch performance through the years. They know every advanced design feature of a Bedford Crane will pay off in safer, smoother, more dependable operation—and they know that every Bedford Crane installed in their plant will be individually engineered and precision built for its specific application.

You are invited to consult a Bedford Engineer on your next crane problem . . . with all the facts on the table, we believe you too will make *your* next crane a Bedford . . . available in all types and sizes, from 5 to 350 tons and up—for all kinds of indoor and outdoor service.

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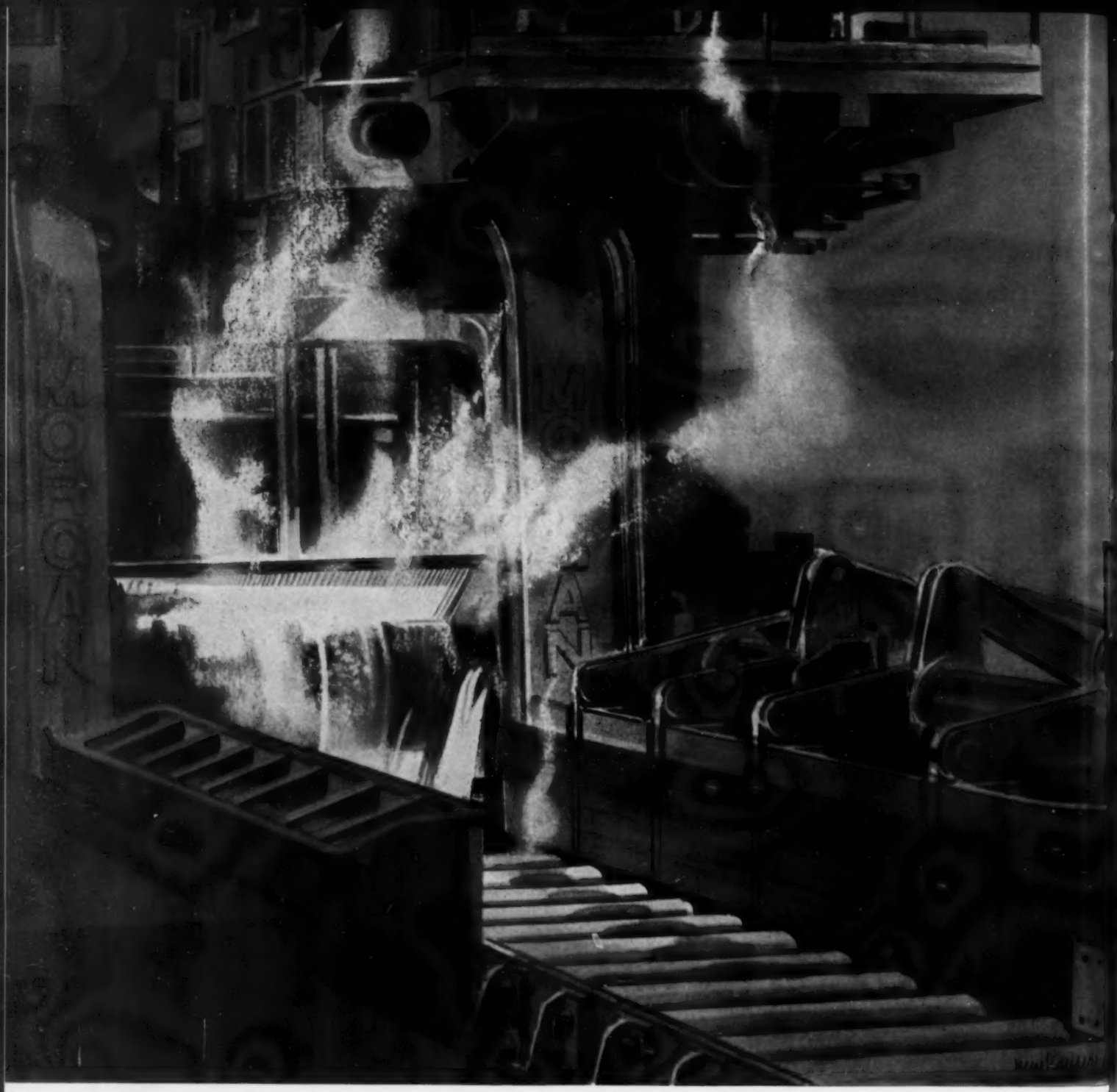

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Morganization now includes a complete survey of your Morgan equipment by experienced Morgan men. The condition of all parts is checked and reported to your maintenance department. Genuine Morgan parts will help maintain the designed efficiency of the equipment. If improvements should be made to increase this efficiency, our engineers will suggest how to make them at lowest cost.

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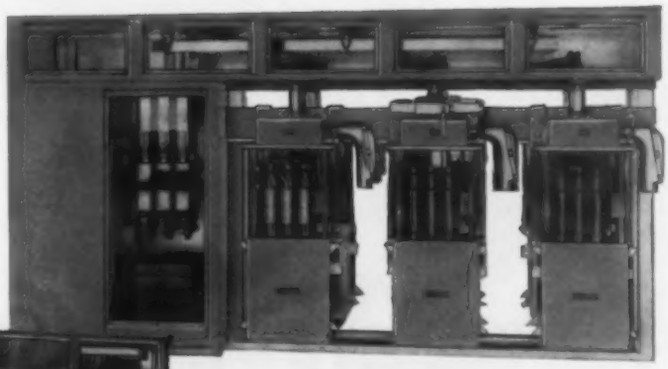
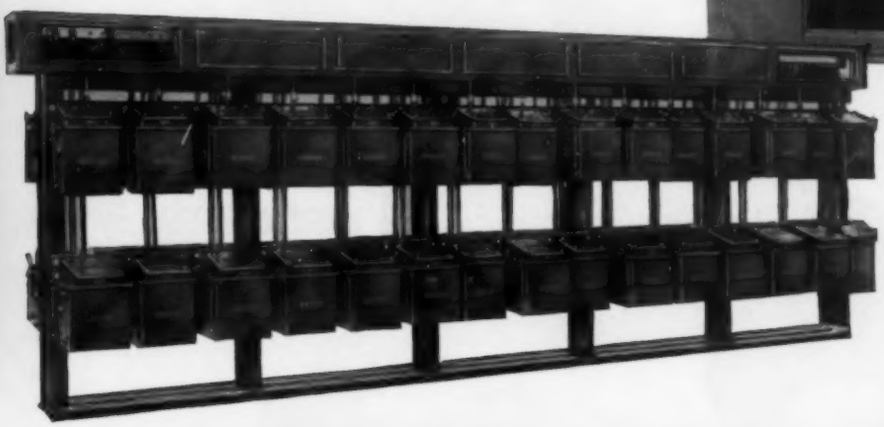
We cordially invite you to visit us at our Booth Nos. 18 and 19 at the 1954 IRON & STEEL EXPOSITION, September 28 to October 1st., inclusive, in the Cleveland Public Auditorium.



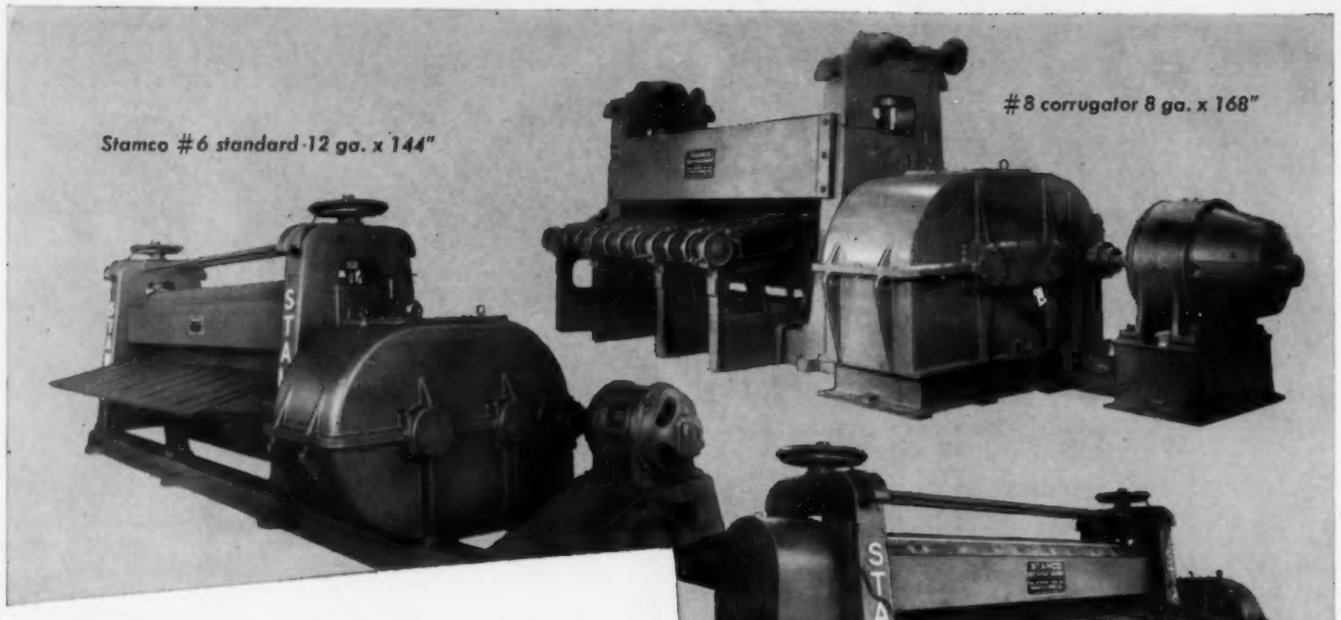


ABOVE — Closed view and open view of a Centralized Control unit showing Disconnect Switches with incoming line circuit breaker for an outdoor application.

LEFT — Closed view of a Centralized Control unit showing Frames 50 and 100, 780-KBF Starters, mounted on a sturdy steel structure.

ROWAN CONTROL

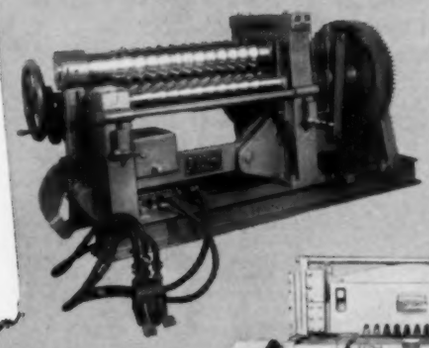
THE ROWAN CONTROLLER CO., BALTIMORE, MD.



For Roll Corrugating and Culvert forming . . . see

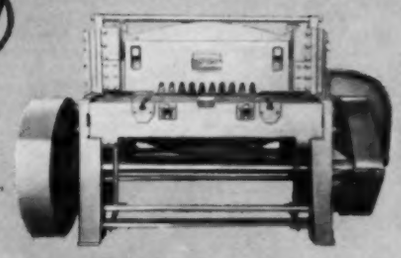
Stamco

Stamco #6A high speed corrugator



Stamco 8 ga. Culvert Curving roll

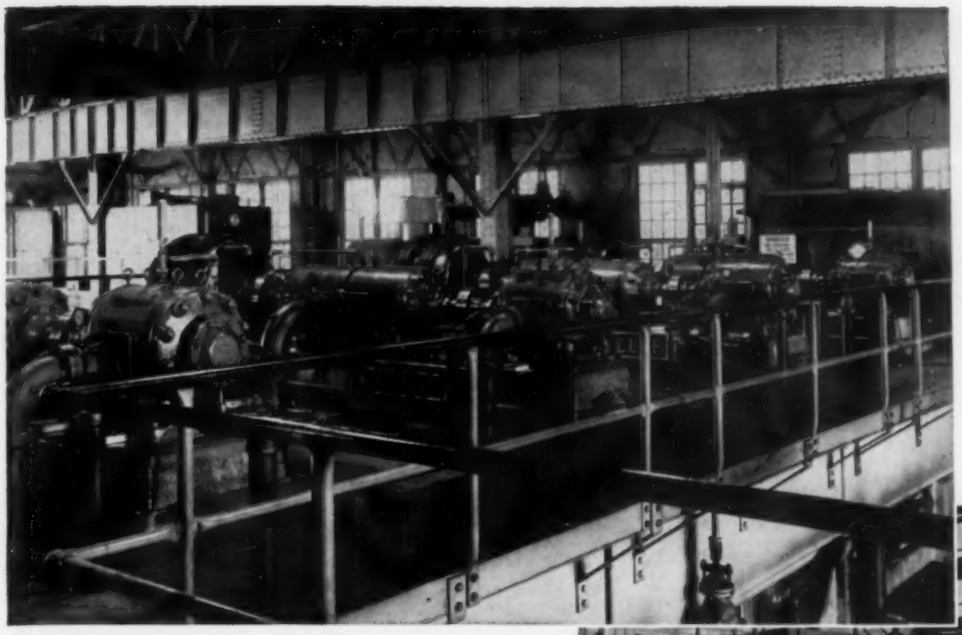
Stamco high duty Culvert Punch and Riveter equipped with air operated friction clutch

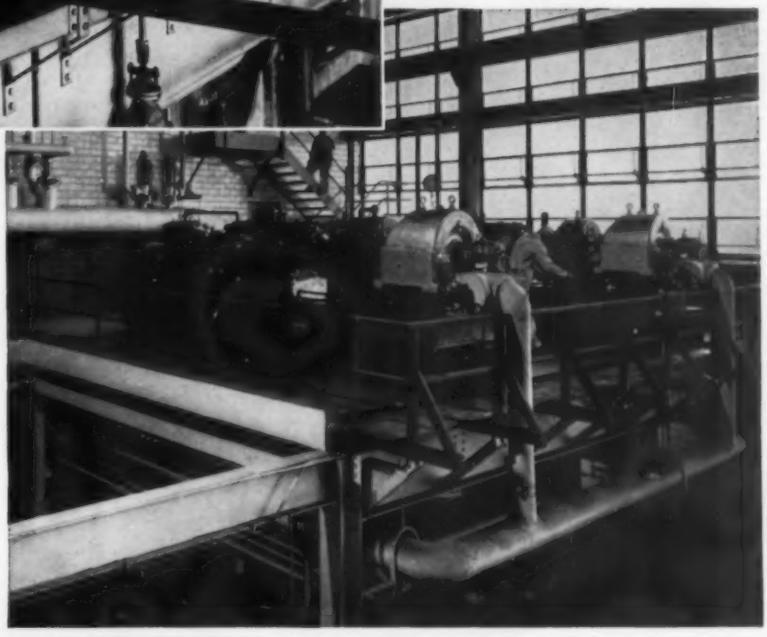


Stamco 8 ga. x 36" corrugated shear

Stamco standard Culvert Punch and Riveter

STAMCO, Inc., New Bremen, Ohio





Views of Fuller Rotaries installed on balconies; overhead, out of the way. Left: Four two-stage; capacity each 1665 c.f.m., 100-lb. psig. Below: Two two-stage; capacity each 1592 c.f.m., 120-lb. psig.

Eliminate heavy, costly foundations with FULLERS

*** simple * compact**

*** direct drive * valveless**

*** vibrationless * pulseless**

If you've never considered the many outstanding advantages of Fuller Rotary Compressors and Vacuum Pumps, now is the time to do so.

Fullers have many unique and beneficial advantages for low cost operation. They can be placed almost anywhere out of the way, because their vibrationless, rotary action permits installation, for example, on a balcony or upper floor of a building . . . no heavy, costly foundations being required. Operated by direct drive, you reduce initial and maintenance costs, as well as transmission losses incident to gear and belt drives.

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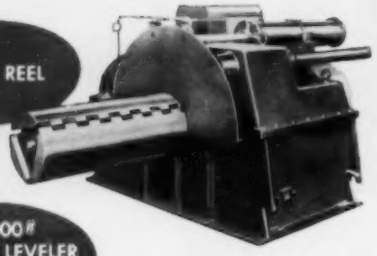
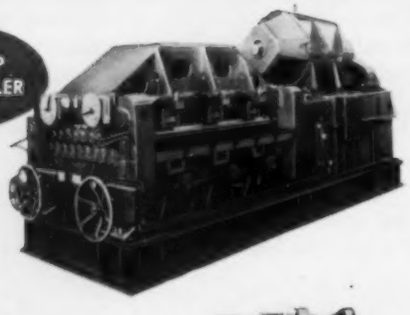
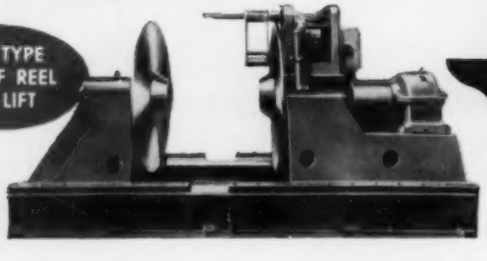


TAKE UP REEL

1,000,000# STRETCHER LEVELER
90" x 240" x 1/4" thick



BACKED UP ROLLER LEVELER



CONE TYPE PAY OFF REEL WITH LIFT

- SLITTER AND SLITTING LINES
- CONTINUOUS PICKLING LINES
- SHEET SCRUBBER LINES
- ROLLER LEVELERS • STRETCHER LEVELERS
- BRUSHING MACHINES • OILING MACHINES
- PAY OFF REELS • TAKE UP REELS
- UP CUT SHEARS • UP COILERS
- UNCOILERS • COIL CARRIAGES
- UP ENDERS • DOWN ENDERS
- EDGING MILLS • TABLES
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SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

17

Pile-ups cost plenty!

...So they prevent them at Gary with RCA Industrial TV

One pile-up at United States Steel Corporation's Gary Sheet and Tin Mill could mean as much as 15 minutes lost production time, or approximately 120 tons of steel! So, at their 80-inch strip mill they installed RCA Industrial TV. This mill holds the world's record for production of hot strip.

A TV screen on the control pulpit (see photo) permits the operator to maintain control of the movement of the hot strip. Television affords the opportunity to keep constant watch and to spot threats of pile-ups before damage occurs. In this way control of strip shape is improved, costly delays are minimized . . . hundreds of tons of steel are saved. The RCA Industrial TV system has been in continuous operation for over a year.

Have you problems of observing operations where it's too hot . . . too dangerous . . . too inaccessible for men to go? RCA Industrial TV permits continuous close supervision of rolling mill operations, furnace combustion, tapping, pouring, and similar hazardous procedures.

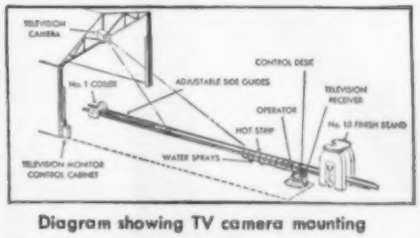

Diagram showing TV camera mounting

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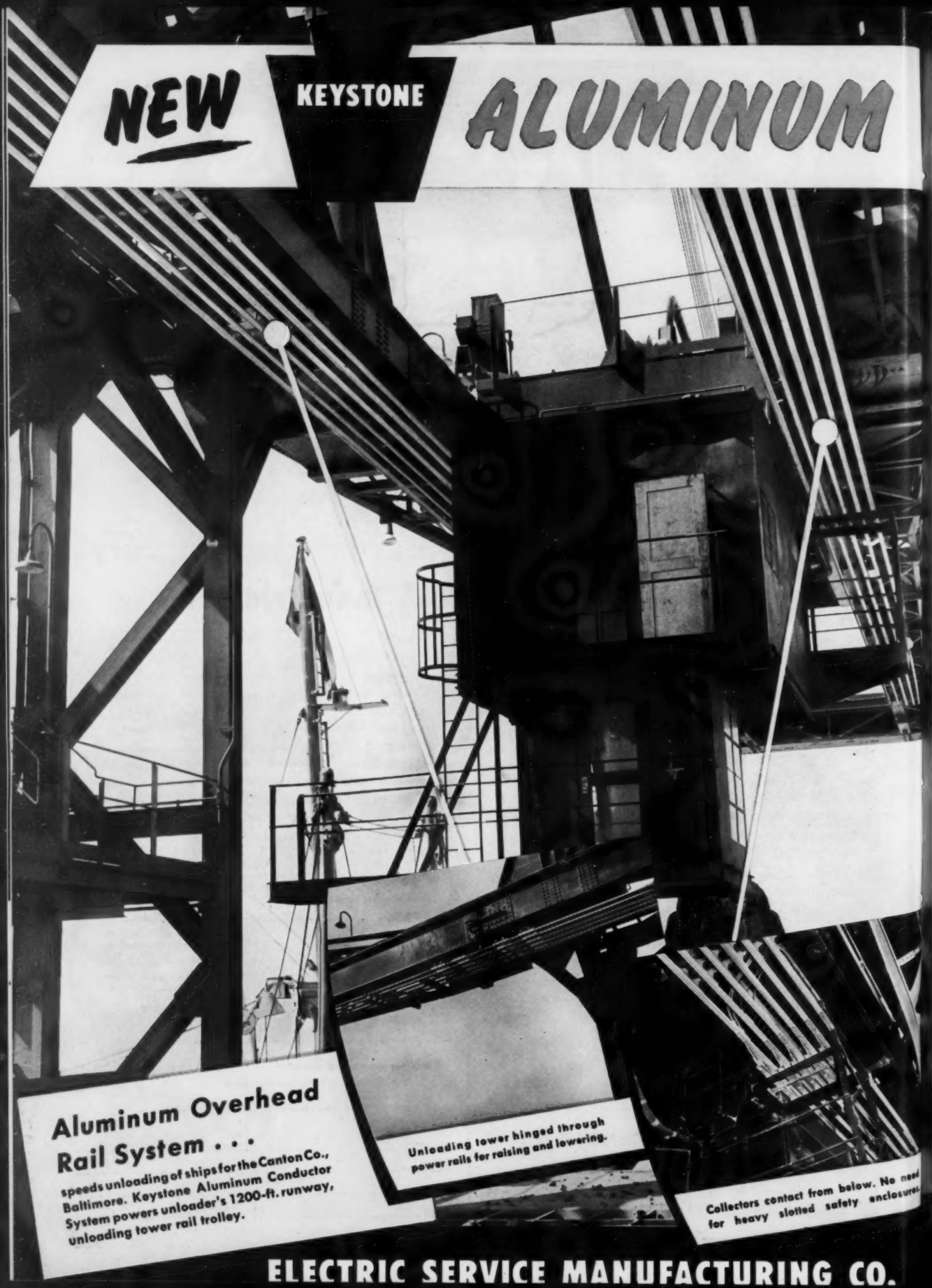
NEW KEYSTONE ALUMINUM



Aluminum Overhead Rail System . . .

speeds unloading of ships for the Canton Co., Baltimore. Keystone Aluminum Conductor System powers unloader's 1200-ft. runway, unloading tower rail trolley.

Unloading tower hinged through power rails for raising and lowering.

Collectors contact from below. No need for heavy slotted safety enclosures.

ELECTRIC SERVICE MANUFACTURING CO.

CONDUCTOR SYSTEM

PROVED 7 WAYS BETTER THAN THE STEEL THIRD RAIL SYSTEM

Here's why it paid the Canton Company of Baltimore to switch from conventional conductors to Keystone Aluminum throughout for their new high-speed ore unloader and 1200-foot-long 2300-volt main runway.

1 CORROSION REDUCED

Salty dampness doesn't faze the Keystone Aluminum System. Cleaner contact surfaces protected from dirt and damage.

2 LOW VOLTAGE DROP

The non-magnetic qualities of the Keystone Aluminum System increase current capacity through lower reactance and close conductor spacings.

3 GREATER CAPACITY

1000 amp rating provides capacity for additional equipment without boosters or multi-point feeds.

4 SENSITIVE CONTROL

Corrosion resistant Keystone Aluminum Systems assure positive contact on most sensitive control circuits.

5 DEADWEIGHT SLASHED

Lighter than steel. Needs no heavy supporting structure. Compact 2300-volt runway safely protected with standard enclosure.

6 LONGER COMPONENT LIFE

Multiple contact collectors prevent arcing and heating. Less vibrating weight saves insulators. Smooth, clean contact surfaces and low current densities mean longer shoe life.

7 INSTALLATION EASED

Compact design, pre-fabricated, lightweight units mean lower labor and installation costs for either open or closed systems.

Could you use this modern system NOW to obtain efficient operation in your construction or improvement program? Write for complete data today on our Keystone Aluminum Conductor System. Our engineers are ready to help you in either the Keystone Aluminum System or the conventional copper or steel system.

Head-on view of traveling crane: unloading tower in position, control car retracted.

Small insulators made feasible through compact, lightweight aluminum system.

Philadelphia 32, Pa.

Represented in Canada by Lyman Tube and

"As Specified"

When photographed, this craftsman in Bethlehem's Forge Specialty Shop was making a final check on a hardened steel roll. It was a big one; requirements called for a body diameter of 38 in., a face of 96 in., and an overall length of 192 in. When he had finished, he could report that all dimensions were "as specified," well within the tolerances permitted.

This forged roll weighed upwards of 22 tons. As you can imagine, it received the most careful handling and checking at every stage of manufacture. Rolls like this require some delicate workmanship, and we are equipped for all the steps that result in a quality product.

Small rolls, too, get expert attention. Bethlehem makes some so small that they can easily be cradled in a man's arms—and of course we also produce every size between the midgets and the giants. Each, regardless of size, must run a gantlet of eagle-eyed technicians. Even the crating and shipping receive unusual attention.

So why not call Bethlehem the next time you require forged rolls? There are no finer made anywhere.

Use Bethlehem forged steel rolls for:

- **Cold-rolling ferrous sheets and strip**
- **Running-down and finishing operations on copper and brass sheets**
- **Hot- and cold-rolling aluminum sheets**
- **Cold-rolling aluminum foil**

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BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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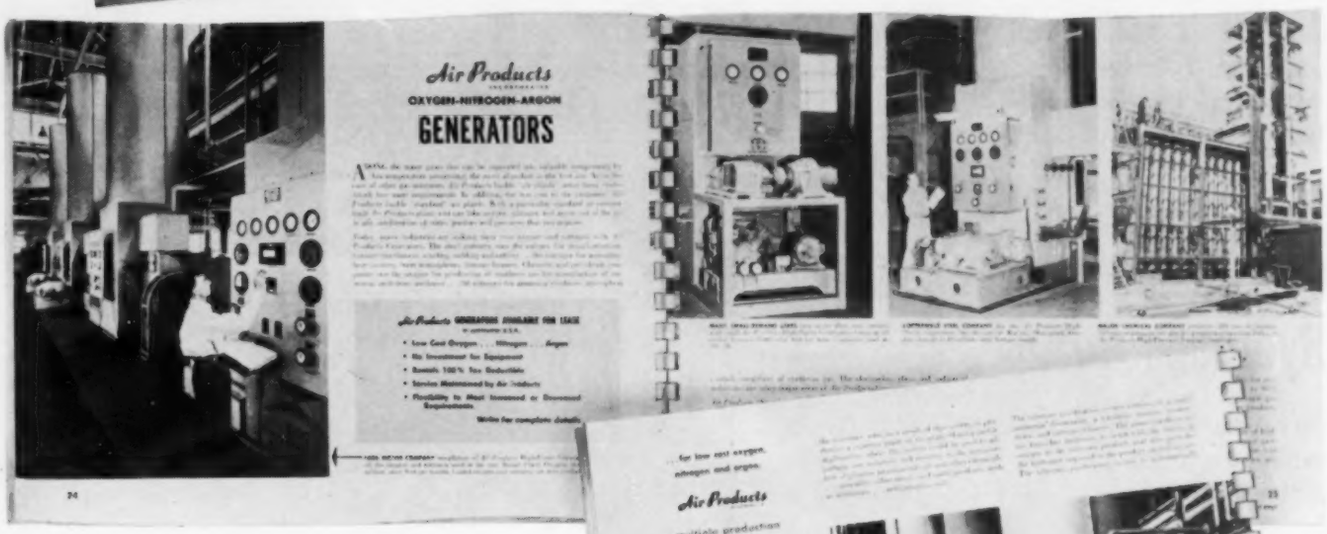
CUT OXYGEN COSTS

Make Your Own!

This free booklet tells you how



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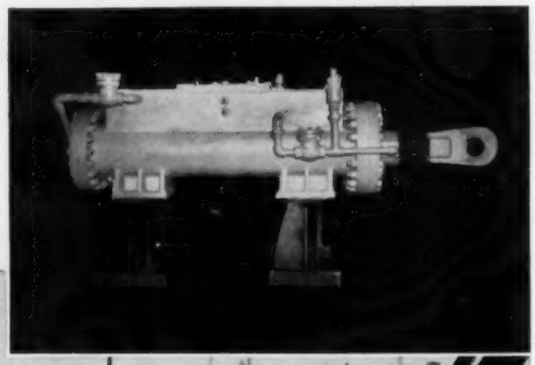
Now — DRAVO HYDRAULIC BUFFERS give safe stops on equipment runways

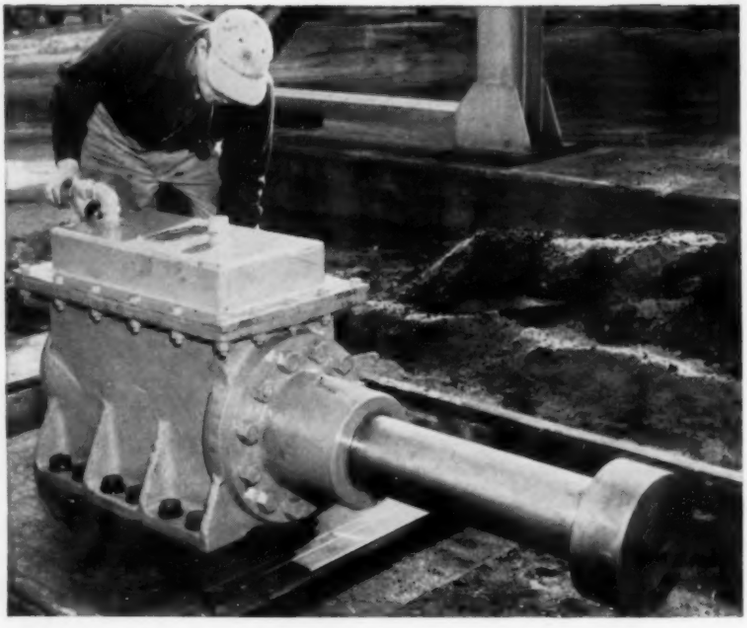
New hydraulic buffers, assuring positive, safe deceleration for all types of traveling equipment, have been developed by Dravo Corporation. In the event of braking failures due to mechanical or electrical reasons, or slippery rails caused by bad weather, the hydraulic buffer acts as an auxiliary brake and eliminates the possibility of severe damage to personnel and equipment plus the resulting repair costs and plant tie-ups.



the DRAVO six-foot-stroke Hydraulic Buffer →

An eastern steel producer installed this pull-type buffer on a 15-ton ore bridge where the 215,000-lb (loaded) man trolley has a top speed of 900 fpm. The trolley strikes a buffer beam connected to the twin buffers and is brought safely and smoothly to a complete stop within six feet. The buffers reset automatically when the trolley travel is reversed.

the DRAVO two-foot-stroke Hydraulic Buffer →



A midwest steel producer needed a smaller, lighter buffer because of space and weight considerations. Dravo designed a two-foot, push-type, direct-contact buffer to meet the requirements of this installation and to produce a safe, although more sudden, stop. A spring reset is used on this buffer.

If your operations are subject to costly accidents due to the need for safe stops of traveling equipment such as man trolleys, overhead cranes, cars, etc., get in touch with Dravo for complete information on the new hydraulic buffers.

DRAVO
CORPORATION
Neville Island, Pittsburgh 25, Penna.

Earle Browning, Manager
Steel Mill Engineering

This hot-strip mill needed smoother control and fewer cobbles

Mr. Browning shows you on the next three pages how Westinghouse apparatus and engineering assistance solved these hot-strip problems.

Westinghouse engineers had ideas for ingot buggy, runout table and coiler

When Westinghouse engineers have complete electrical responsibility, they can coordinate drives and regulating systems for the complete mill. You benefit from a boost in production, a smaller scrap pile, a mill that's easy to run.

Remote controlled ingot buggies are a step toward automation. The operator of the ingot crane, above the soaking pits, runs the show. He presses a button, and the buggy slides beneath him and stops. After loading, he presses another button, and the buggy departs to drop its ingot onto the table in front of the mill stands. Meanwhile, the crane finds a new position. The empty buggy will obediently follow it to that spot. Or the operator may ask the buggy to wait.

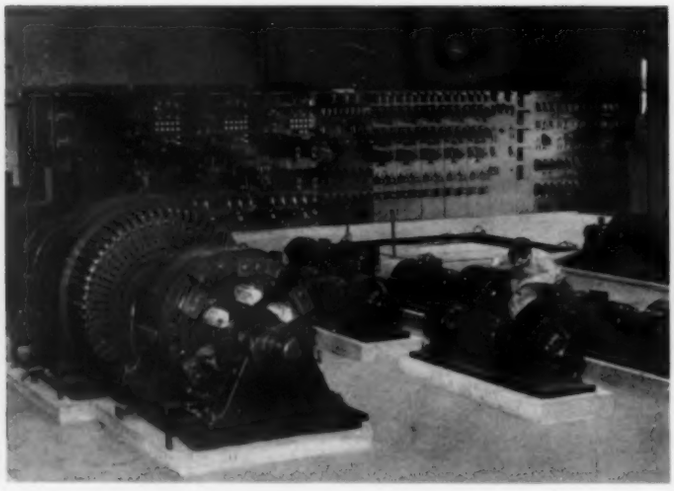
Main elements of this control are two parallel and sectionalized control rails. One is contacted by the cranes in their travel, and the other, with matching sections, provides the buggy control. These two rails form two legs of a Wheatstone's bridge. When the controlling crane and the buggy are in different locations, an unbalanced current flows. This current hurries the buggy along its track until the unbalance disappears.

To handle wide strip ranges needed on high-speed, hot-strip mills, Westinghouse has a full line of drive equipment. D-c motors driving the stands are supplied either with Ignitron rectifiers or d-c generators driven by synchronous motors. Westinghouse Rototrol® provides the precise synchronization between mill, table and coiler drives required when the strip is in both the mill and coiler and after the strip leaves the last stand of the finishing train and races into the coiler located near the mill. Westinghouse engineers carefully match all drive characteristics and coordinate the total system with Rototrol regulators.

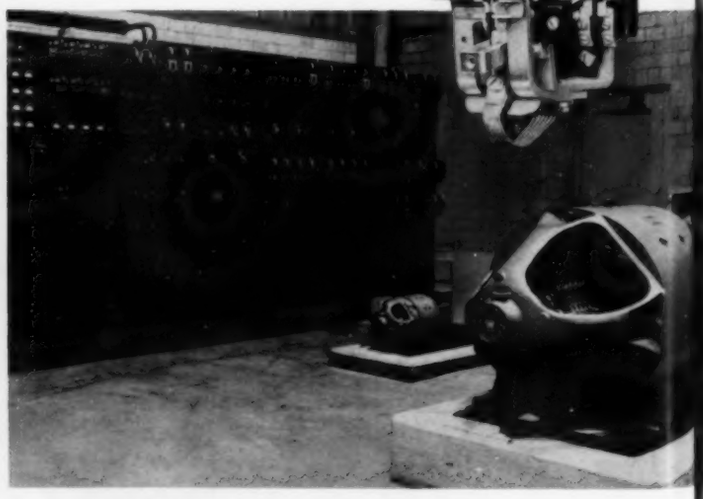
Rototrol licks a lot of mill control problems. With runout table rolls and coiler mandrels driven by individual d-c motors, each controlled by adjustable voltage, the load shifts as the strip zips from the mill along the table and to the coiler. Rototrol regulates for the speed changes and inertia effects that cause looping and cobbling. As a result, the speeds of the tables and coilers always bear a definite relationship to the speed of the mill. Simplifies your operation.

YOU CAN BE **SURE**...IF IT'S

Westinghouse

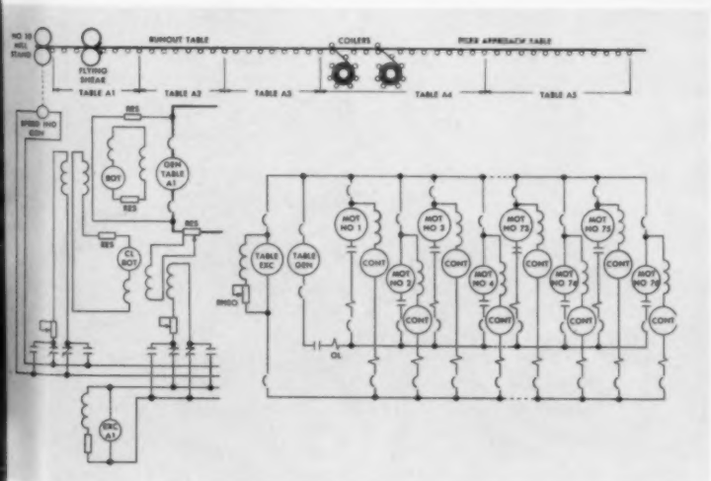


Ingot buggy control is visible at the board's left end. Rototrol regulating sets and the power supply motor generator set are in the foreground. The operator inspects one of five Rototrol m-g sets.

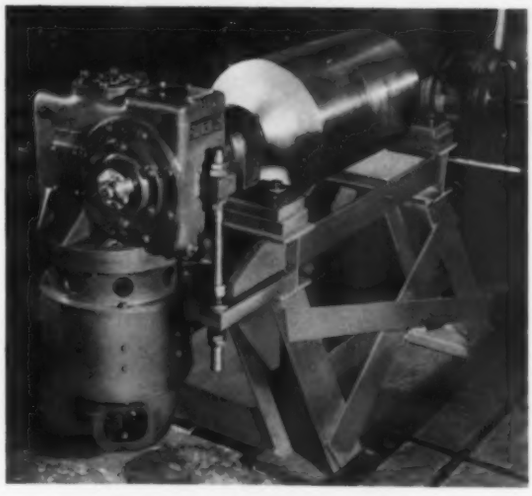


22-panel adjustable voltage control regulates runout tables and coilers. Current-limit Rototrols accelerate or retard the drive. Inset: Type M d-c contactor, a Westinghouse control line component.

700 Westinghouse d-c runout table motors each drive an individual roll on this runout table. Motors are 4-hp, adjustable voltage, totally enclosed, watertight. Each section's speed is synchronized automatically with the stand speed by this coordinated adjustable voltage system.

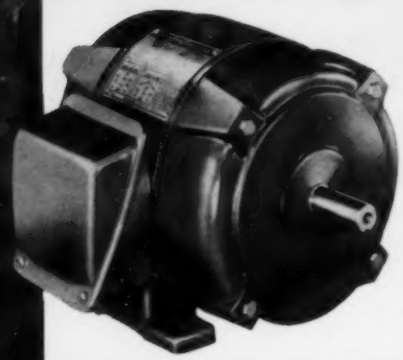


Westinghouse Rototrols match table and coiler speeds to the mill speeds. Each table section and each coiler are supplied power by an individual direct-current induction generator.

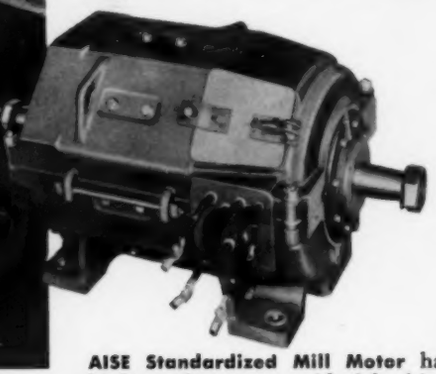


New floating-type gearmotor matched to a high-speed motor gives you an economical drive. This unit (right-angle type with worm gearing) floats with the roll. It assures alignment, saves space.

Flying shear is controlled from this desk, located in the pulpit. Both the roll diameter compensating and the cut-to-length potentiometer rheostats are in front of the operator.



New Life-Line® "A" motor has frame, feet and end brackets of heavy cast iron. Other new Westinghouse features: Bondar insulated wire; unitized stator; balanced, die-cast rotor; pre-lubricated bearings.



AISE Standardized Mill Motor has high starting torque—ideal for high inertia loads. Its simplified construction makes servicing and maintenance easy, and it performs efficiently under toughest conditions.

Flying shear and mill speeds are matched by Rototrol

On this new flying shear setup, a speed-indicating generator, mechanically connected to the last finishing mill stand, has its voltage bucked against another speed-indicating generator coupled to the shear drive. Any difference in voltage between these generators actuates the Rototrol-electronic regulator to increase or decrease the shear speed as required. A single motor forms the Westinghouse flying shear drive. It's located in the motor room—a cleaner, less cramped area. The shear is accelerated to speed in approximately three-quarters of a second. It stops just as quickly. An operation like this cuts scrap losses.

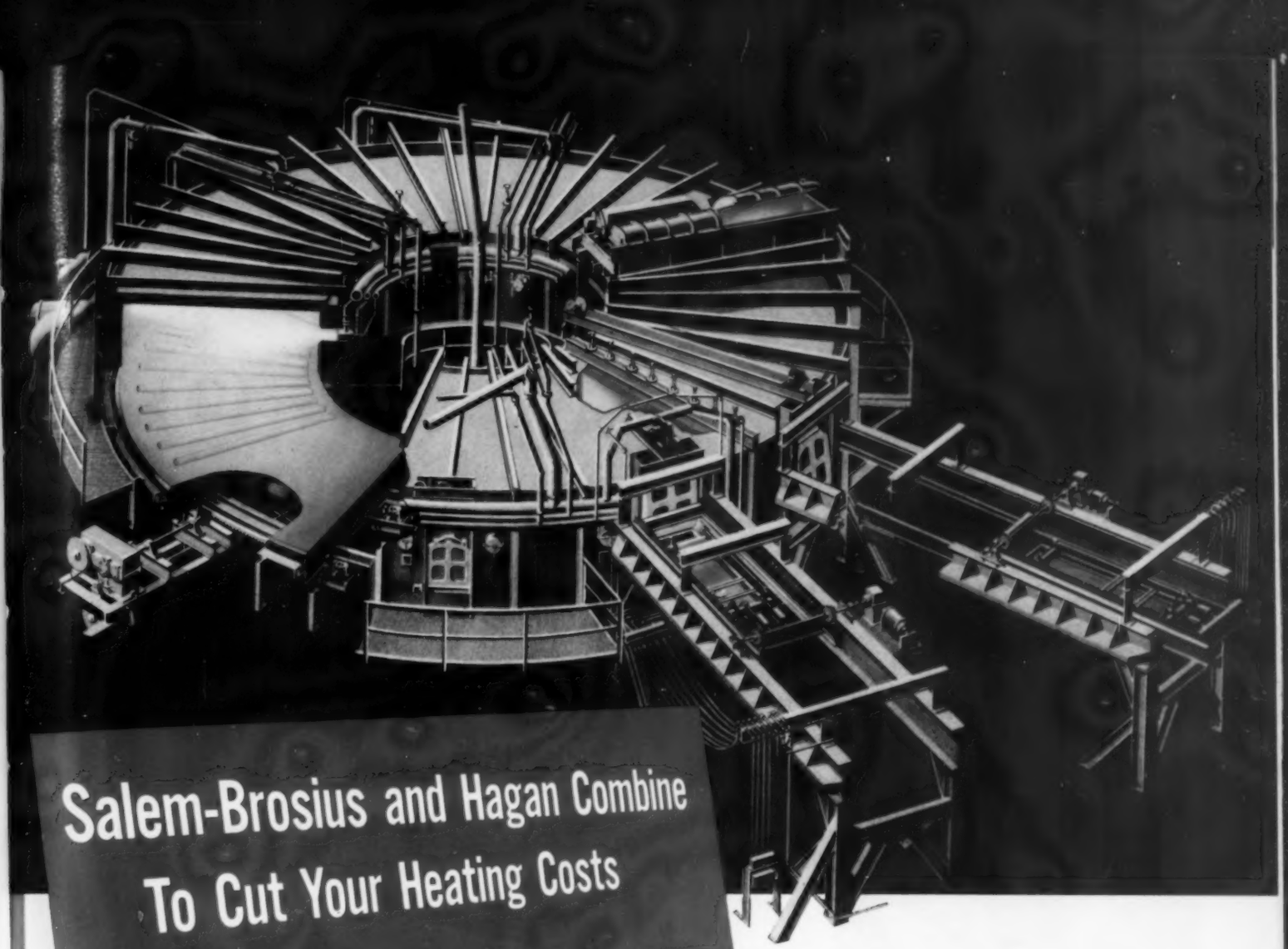
Westinghouse maintenance service will keep this rugged apparatus at peak performance. Westinghouse has 31 Renewal Parts Warehouses, 38 Repair Plants, and 56 Field Service Offices. Put our facilities to work for you. Phone your nearby Westinghouse representative. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

MP-3017

YOU CAN BE **SURE**...IF IT'S Westinghouse

Perry Croco, Engineering Manager in the Westinghouse Pittsburgh office, backs up the salesmen in his territory with first-class steel engineering help. Put him—or his counterpart in your area—to work for you. Ask your Westinghouse representative for these booklets: **Rototrol in the Steel Industry (B-3998-B), Westinghouse Gearmotor (B-5645), Complete Industrial Control (B-6051), New Life-Line "A" Motor (B-6154), Magamp in the Steel Industry (B-5468), Mill Motors and Controls (B-4730)** or write to: Industrial Products Advertising, Westinghouse Electric Corp., Box 868, 3 Gateway Center, Pittsburgh 30, Pa.

MP-3017



Salem-Brosius and Hagan Combine To Cut Your Heating Costs

When Salem-Brosius recently purchased the George J. Hagan Company, some of the finest furnace engineering brains in the world were consolidated into a single team to bring you the best in industrial heating at the lowest initial and operating costs.

Take, for example, the massive rotary hearth furnace illustrated here. Salem-Brosius' new combined engineering group has designed almost all of these furnaces—not only in the United States but all over the world. This type of furnace ranges from 5 to 90 feet in diameter, and can be used for a wide variety of metal and metal part heating and heat treating jobs.

The circular shape saves valuable plant floor space. Fuel efficiency is unparalleled by any other type of furnace. Heating is rapid and uniform. Automaticity of control drastically cuts labor costs. And good design with good construction minimizes maintenance expenses. All of these benefits together spell higher furnace output at lower cost—and greater profit to you, the user.

If your plant modernization or expansion plans call for heating or heat treating furnaces of any kind, furnace charging machines, forging manipulators, hot materials handling equipment, large diameter gas main valves, or other special machinery or furnace equipment, write, wire, or phone Salem-Brosius!

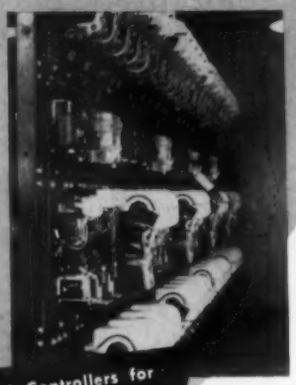
SALEM-BROSIUS, INC.

EXECUTIVE OFFICES: 248 FOURTH AVENUE, PITTSBURGH 22, PA.

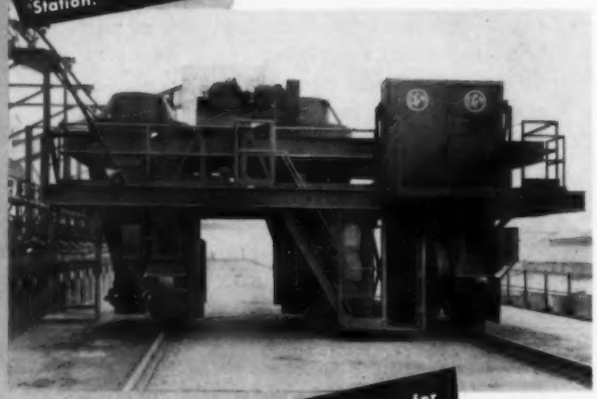
Coke Pusher built by Wellman Engineering Company, for the Wilputte Coke Oven Division. Door-Machine is in left foreground.

Improved Operation

A GOOD REASON FOR SPECIFYING EC&M CONTROL FOR COKE OVENS



EC&M Controllers for automatically operating four car-hauls at the Coke Screening Station.



Koppers Larry Car for charging coal into ovens.

These coke oven machines are operated by EC&M Controllers using EC&M LINE ARC Magnetic Contactors and EC&M TIME-CURRENT method of acceleration.

EC&M Control has the reputation for being accurately engineered for the job and likewise designed for long life. This quality apparatus is known for its low upkeep.

When buying new machines or revamping existing installations, it pays to specify EC&M Control equipment.

THE ELECTRIC CONTROLLER & MFG. CO.

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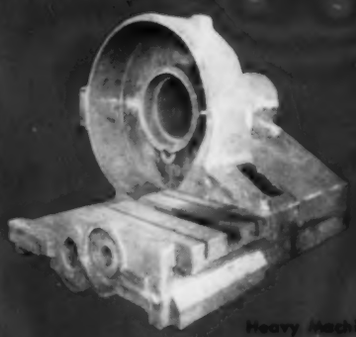
Hyde Park
ROLLS and ROLLING MILL EQUIPMENT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For more than fifty years Hyde Park has built only the best.
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	• Merchant Mills	• Guillotine Shears
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	• Pinion Stands	• Roll Lathes
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GRAY IRON CASTINGS UP TO 80,000 LBS.	• Machinery Castings	• Mill Housings
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	• Housings	• Lay-out Plates
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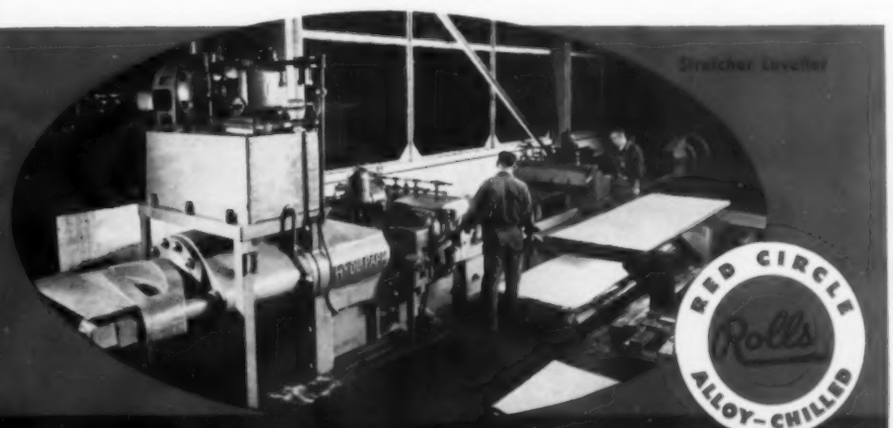

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THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO • Plants at Lima and Springfield, Ohio

Industry News...

MODERNIZATION PROGRAM AT WEIRTON STEEL INCREASES CAPACITY OF TWO TINNING LINES

▲ Capacity and operating speed of two electrolytic tin plating lines were increased through a modernization program recently completed at the tin mill of the Weirton Steel Co.

On No. 4 line, the company's newest, four plating cells were added. Prior to the improvement project, No. 4 consisted of 24 plating cells with 24 generators of 7500 amperes capacity.

The motor generators were replaced with 9000 ampere units, and four generators were added for the four new plating cells. No. 4 line now consists of a total of 28 plating cells and 28 generators of 9000 amperes each.

Increasing the size of the generators resulted in a power increase of approximately 50 per cent, making it possible to run a larger percentage of strip steel through the tin coating line at maximum operating speed. The heating capacity of the reflow tower, where the tin plate receives its shiny surface through a re-melt process, was also increased to correspond with the step-up in power of the generators.

The tin mill project also included construction and erection of a new plater frame on No. 3 line similar to the more modern arrangement of No. 4, and installation of new plating cells and rolls. The frame is mounted on a rubber-lined steel foundation pan, 100 ft long by 22 ft wide.

Twenty-four 5000 ampere generators were removed from No. 3 line and replaced by the twenty-four 7500 ampere generators that were removed from No. 4 line.

FIRST COKE PUSHED AT NEW CAMPBELL OVENS

▲ The first heat was pushed August 12 from a new 76-oven, by-products coke battery at the Campbell Works of the Youngstown Sheet and Tube Co. in Youngstown, Ohio. The battery has a daily capacity of 1250 tons of coke, or about 450,000 tons a year.

The ovens have 730 cu ft of capacity, about one-third larger than the Campbell plant's older ovens, and have underjet firing. The battery is over 350 ft long.

Before the new battery was tied into the operations, there were six batteries of 51 ovens each at the Campbell locations which were constructed in 1916 and 1917.

The new ovens are 43 ft 2⅜ in. long, 13 ft 2⅜ in. high and average 18 in. in width. The adjoining coal storage building has a capacity of 2200 tons. The draft stack is 250 ft high and has a diameter of 11 ft. It is of concrete construction with brick lining.

On hand for the first push were J. L. Mauthe, president of the Youngstown Sheet and Tube Co.; M. S. Curtis, assistant to the president; H. E. Engelbaugh, Youngstown district manager; H. H. Waldschmidt, director of purchases and J. S. Stanier, general superintendent.

Superintendent of the Campbell coke plant is C. A. Covington. His assistants are A. H. Parthum and J. F. Major.

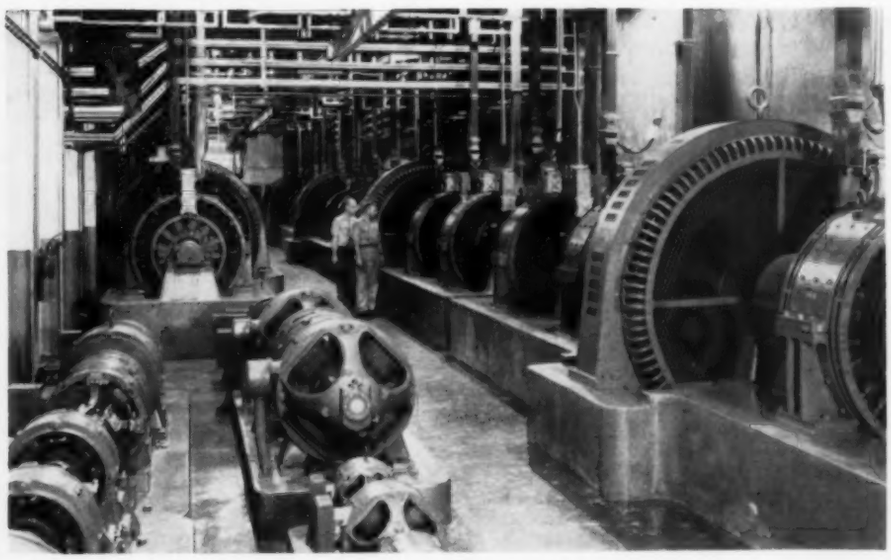
MOBILE TERMINAL BEGINS NORMAL ORE OPERATIONS

▲ Normal operation was begun August 9 at the Mobile Ore Terminal of the Tennessee Coal & Iron Division of the United States Steel Corp., according to Arthur V. Wiebel, of Birmingham, TCI president.

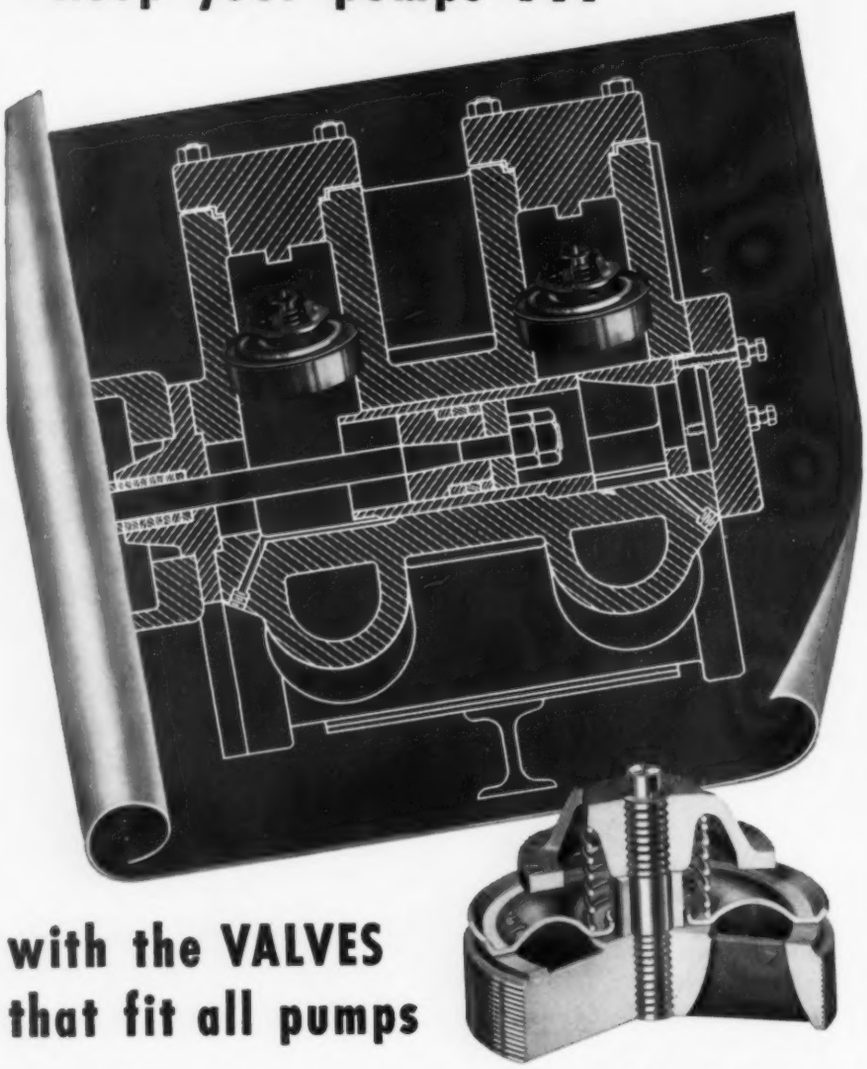
Arrival of the SS Ore-Chief, first of the big vessels to be used in conveying iron ore from Puerto Ordaz, Venezuela, to the TCI Ore Terminal, signified the beginning of routine functioning of the terminal and its unloading facilities. Trial operation, including the handling of ore shipments by vessels of smaller tonnage, has been underway at the terminal for several weeks, Mr. Wiebel said.

The Ore-Chief docked at the new terminal with a cargo of 21,000 gross tons of the Venezuelan iron ore from United States Steel's Cerro Bolivar operations. Capacity of the Ore-Chief is 47,500 gross tons at 34 ft draft, and ultimately it is anticipated that full loads will move through TCI's Mobile terminal for use in the division's iron and steel operations at Birmingham. The ore is transshipped by rail

Some of the twenty-eight 9000-ampere generators which supply power for the 28 plating cells of Weirton Steel Co.'s No. 4 electrolytic line. The new generators were recently installed along with four additional new plating cells. Twenty-four 7500-ampere generators that were taken from No. 4 were placed at No. 3 electrolytic line. The rehabilitation increased the capacity of both lines.



Keep your pumps FIT



with the VALVES that fit all pumps

Your old reciprocating pumps can be rehabilitated or adapted to new and severe service by fitting them with DURABLA Pump Valve Units.

The patented corrosion-resistant, non-warping, pressed metal valve, making only "point contact" on the stud or sleeve, cannot bind or hang up on the guard stem. The open-type guard assures free flow of liquid and eliminates any possibility of spring clogging from hardening liquids.

DURABLA Pump Valves will operate freely under extremes of high or low temperature, with highly corrosive fluids, and in any position. They will handle vacuums of one micron or discharge pressures of thousands of pounds per square inch.

Standard equipment on many pumps, DURABLA Valve Units are made in fifteen sizes, designed to meet over 300 variations in installation requirements. They will fit any reciprocating pump, new or old.

A DURABLA engineer will be glad to help you work out a plant survey covering your valve requirements. Write for bulletin or engineering assistance.

DM-2

DURABLA

DURABLA MANUFACTURING COMPANY

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or barge from Mobile to the upstate furnaces.

Contracts for installing the ore terminal facilities were let in October, 1951. Dravo Corp. installed the trolley type ore unloader.

Iron ore imported through the new terminal contains up to 60 per cent iron, Mr. Wiebel said. He explained that it is blended in Birmingham with lower grade local ores, the maximum iron content of which runs to 36 per cent.

Marine Bulk Handling Corp. will operate the terminal under contract with TCI.

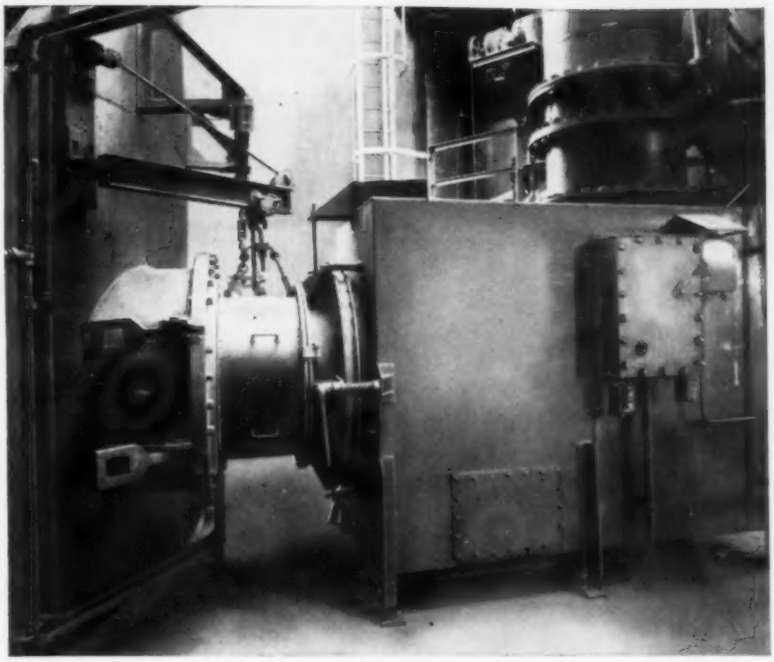
McLOUTH EXPANSION TO FEATURE GE UNITS

▲ More than $4,000,000 worth of electrical equipment for McLouth Steel Corp.'s new cold strip mill expansion at Gibraltar, Mich., will be furnished by General Electric Co. during 1954 and 1955.

The largest and most important mill in the Gibraltar plant expansion will be a four-stand tandem mill. The mill will change a ¼ mile long, ⅛-in. thick strip into a strip one mile long, and $\frac{1}{32}$-in. thick every four minutes. The output of this tandem mill will be further processed in annealing furnaces, two skin pass mills, two shearing lines, and two slitting lines.

The 19,700 hp of the main drives make it the third highest powered tandem mill in the world. Only two others are larger, having 21,650 hp each. Most of the strip to be rolled will enter at 0.120 in. thickness by approximately 58 in. wide, and leave at a thickness of 0.030 in. The delivery speed for this amount of reduction is approximately 1800 rpm. For schedules where the reduction is less, the mill will deliver at a top speed of 3300 fpm. Nearly all of the 0.030 in. stock delivered will be destined for use in automobile bodies.

The tandem mill control has been "pepped up" by using 360 cycle static amplistat regulators, preamplifiers and new design amplidynes for the power amplifiers. The voltage regulator supplied by G.E. with previous mills, with one exception, were all amplidyne and had a speed of response of about ¼ second. The voltage regulator for this new tandem mill, with its 360 cycle amplistats and new amplidyne, will have a speed of



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Accumulated
Experience of

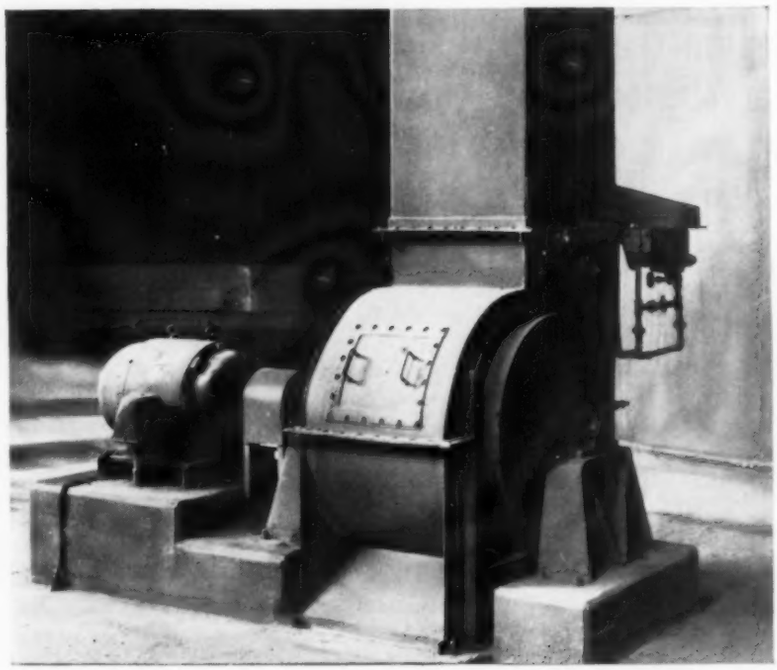
25 YEARS

IN THE DESIGN,
MANUFACTURE
AND INSTALLATION
OF OVER

500 UNITS

IS INCORPORATED
IN THE

Freyn-Design
BLAST FURNACE STOVE BURNER



*

AVAILABLE
IN CAPACITIES
FROM 8,000 TO
25,000 CFM GAS

*

TWO-THIRDS
OF SALES
HAVE BEEN
REPEAT
ORDERS

METALLURGICAL PLANT DESIGN AND CONSTRUCTION

KOPPERS

KOPPERS COMPANY, INC.
Freyn Engineering
Department

KOPPERS BUILDING • PITTSBURGH 19
100 NORTH WABASH AVENUE • CHICAGO 2

Associated with Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND
De Lattre & Freyssinet, Paris, FRANCE

NEW SUTTON 7-Roll
STRAIGHTENERS

FOR ACCURATE END TO END STRAIGHTENING
OF STEEL OR NON-FERROUS TUBES
OR ROUND BARS
AVAILABLE IN ALL SIZES
For 5/16" to 20" O.D. Tubes
For 5/16" to 12" Dia. Bars
SUTTON
MODEL 4 KTC (pictured)
TUBES FROM 3 3/8" O.D. to 12" O.D.
BARS FROM 3 3/8" to 7 1/2" Dia.

Patented cluster roll arrangement positively confines work to pass line from entry to delivery without guides. Roll angles are automatically adjusted to proper setting with full contact between work and rolls.

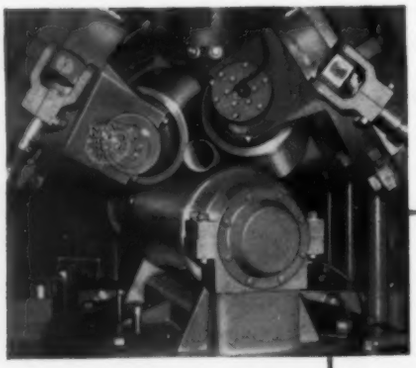
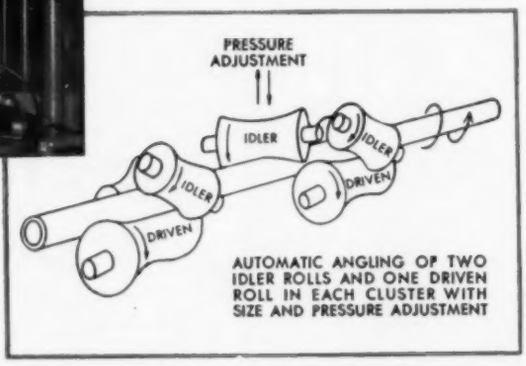


Photo and diagram of 7-roll design shows engineering principle of cluster roll arrangement.

- TRULY GUIDELESS
- HIGH PRODUCTION
- QUALITY STRAIGHTENING



Ask for Bulletin No. 25

SUTTON Engineering COMPANY

Manufacturers for Ferrous and Non-Ferrous Metal Industries

STRAIGHTENERS, EXTRUSION PRESSES, HYDRAULIC STRETCHERS,
SHEET LEVELLERS, GAG PRESSES, ROTARY CLEANERS,
HEAVY-DUTY UNIVERSAL JOINTS, ROLLS.

BELLEFONTE, PENNSYLVANIA

response between 0.1 and 0.2 second. Engineers report that analyzer studies have shown this speed of response to be the point of diminishing returns.

In addition to the electrical equipment for the various mills and processing lines, General Electric also supplied equipment for a complete lineup of 7.2 kv Metal-Clad switchgear, four 1500 kva unit substations, one 1500 kw pumpless tank rectifier substation, complete ventilating equipment and complete installation drawings.

PLAN USE OF ATOMIC REACTOR IN STEELMAKING

▲ Application for authority to use an atomic reactor in connection with the making of steel in a proposed new plant to be erected in the Chicago area was made to the Atomic Energy Commission by World Steel Corp. of Chicago.

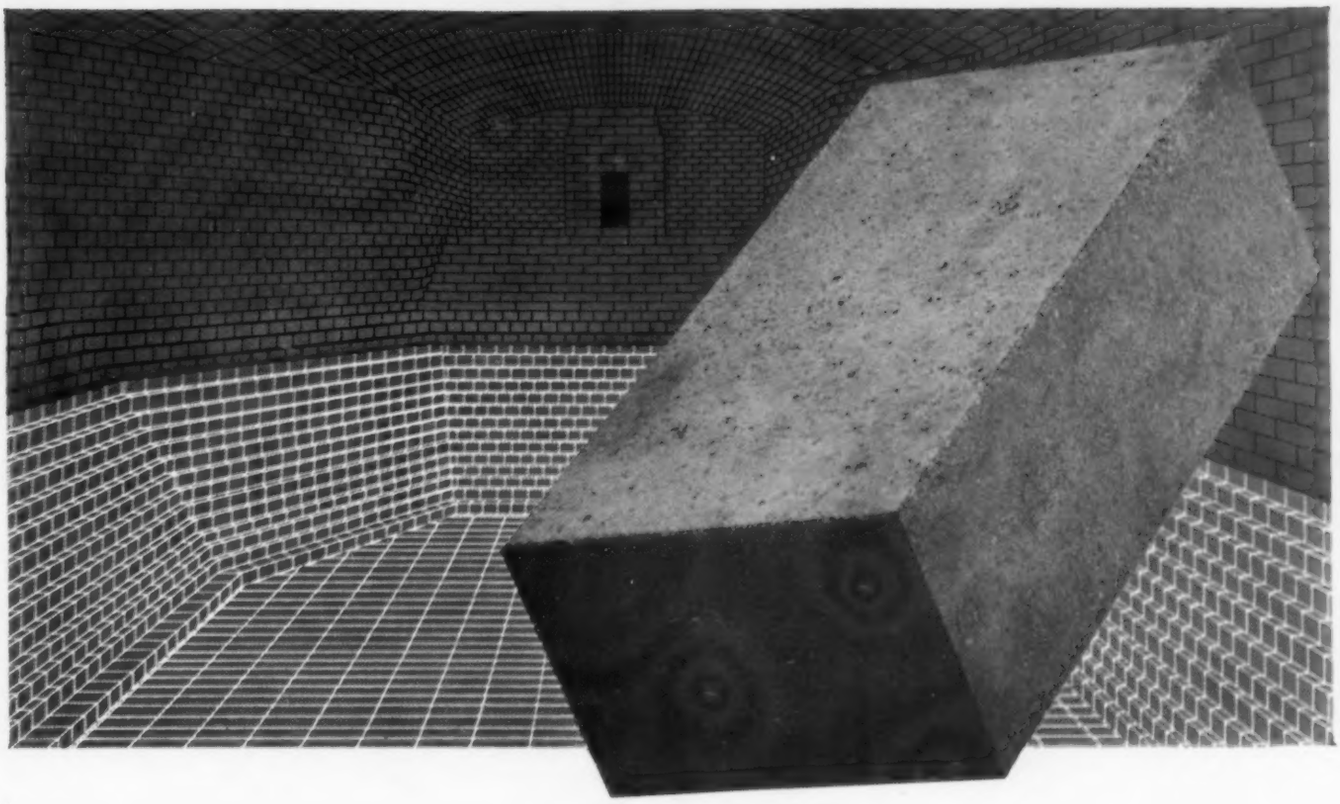
World Steel plans to use this atomic reactor for heating water into steam and thus operate turbines to generate electric power. It is understood that one ton of uranium in a reactor would produce as much energy as 5000 to 10,000 tons of coal.

KAISER TO CONSTRUCT ALUMINUM ROLLING MILL

▲ A new multi-million dollar aluminum sheet and foil rolling mill on a 2500 acre Ohio River frontage near Ravenswood, W. Va., will be built by Kaiser Aluminum & Chemical Corp., according to an announcement by D. A. Rhoades, vice president and general manager.

The new mill is a major step in the expansion of the corporation's fabricating facilities to meet the growing demand for all types of aluminum products. It will substantially increase the company's existing sheet and foil capacity which is now concentrated on the West Coast. The new plant will be Kaiser Aluminum's third fabricating facility located in the large aluminum consuming industrial centers of the East and Middle-West. The others are the Newark, Ohio, rod, bar, wire and electrical conductor plant, and the Halethorpe, Md., extrusion plant.

The site for the new plant has been acquired and actual construction is



GET EXTRA SUB-HEARTH SAFETY WITH PERMANENTE PERICLASE D-S BRICK!

MAJOR STEEL COMPANY ceramists have found that Permanente Periclase D-S Brick meets their requirements for the safest, most efficient sub-hearth refractory.

This superior brick is being used in open hearths of leading steel producers because it gives *maximum protection against costly breakthroughs, gives longer sub-hearth life.*

Permanente Periclase D-S Brick has been *designed especially* to withstand conditions that exist in the sub-hearth and up to the slag line. It is made from pre-shrunk, accurately-sized Periclase grains derived from sea-water magnesia and has all the properties outlined by ceramists as most desirable.

Among these properties are:

High MgO—Contains more than 95% MgO (165 pounds of MgO per cubic foot of brick).

Chrome-free—Eliminates the reduction of chromium oxide when sub-hearth brick is in contact with molten pig iron or high carbon steel. Under these conditions, chromium would be absorbed by the bath with resultant damage to the refractory structure. Carbon monoxide generated during a heat penetrates to the sub-hearth and also reduces chromium oxide in chromite-bearing brick. (Brick contains only 0.8% Cr_2O_3).

Low iron oxide—Minimizes the effect of alternate oxidation and reduction of iron oxide and other iron compounds which can cause damage to refractory brick. (Brick contains only 0.6% Fe_2O_3).

Low calcium oxide—No refractory damage caused by slaking during a slow heat-up or while the furnace is idle. (Brick contains only 1.2% CaO).

With all its many advantages, Permanente Periclase D-S Brick gives you the ultimate in sub-hearth safety and durability—yet costs no more.

Write for full information. *Kaiser Chemicals Division,* Kaiser Aluminum & Chemical Sales, Inc. Regional sales offices: OAKLAND 12, California, 1924 Broadway; AKRON 8, Ohio, First National Tower Bldg.; CHICAGO, 518 Calumet Bldg., 5231 Hohman Ave., Hammond, Indiana.

Kaiser Chemicals

Pioneers in Modern Basic Refractories

Basic Refractory Brick • Ramming Materials • Castables & Morters • Magnesite • Periclase • Deadburned Dolomite

AUTOMATION is a 20 YEAR OLD FACT at PRATT & WHITNEY

The *name*, perhaps, is new, but AUTOMATION . . . with "feedback" control and automatic adjustment . . . has long been a practical working *fact* at Pratt & Whitney. Nearly 20 years ago, for example, P&W Syncro-Timer Control Units, operating in conjunction with P&W Continuous Gages, were successfully applied to the completely automatic classifying and sorting of tin plate on shearing lines. P&W Gages and Control Units that automatically correct the thickness of coating insulation on extruded wire went into operation 8 years ago.

TODAY we are successfully applying the same basic principles to automatically control the screwdowns on tandem and reversing cold strip mills to insure uniformity of product.

No . . . you don't have to wait for *automation* to happen. Its opportunities for added efficiency, improved product quality and lower costs are available *RIGHT NOW* via Pratt & Whitney. Installations are compact, simple and inexpensive. Take advantage of our wide experience. Call in the Pratt & Whitney Specialist now. There is no obligation.

PRATT & WHITNEY
DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONNECTICUT, U. S. A.
SINCE 1860

First Choice for Accuracy

BRANCH OFFICES AND STOCK . . . BIRMINGHAM* • BOSTON • CHICAGO
CINCINNATI • CLEVELAND • DALLAS (The Stanco Co.) • DETROIT • LOS ANGELES
HOUSTON (The Stanco Co.) • NEW YORK • PHILADELPHIA • PITTSBURGH
ROCHESTER • SAN FRANCISCO • ST. LOUIS • EXPORT DEPT., WEST HARTFORD

MACHINE TOOLS • CUTTING TOOLS • GAGES

scheduled to start around January 1, 1955, with the first stage to be completed by mid-1956.

The initial facility will have a rated annual capacity of 72,000,000 lb of light gage aluminum sheet and foil and will be supplied with heavy gage coiled sheet known as re-roll stock from the corporation's Trentwood, Wash., plant where excess hot rolling capacity is available.

ANNOUNCES EXPANSION PROGRAM AT DELTA-STAR

▲ A $250,000 expansion program at Delta-Star Electric Division, H. K. Porter Co., Inc., of Pittsburgh, has been announced by C. S. Beattie, vice president and general manager. The expansion program includes 15,000 sq ft of additional assembly floor space, the modernization of structural steel fabricating plant and the installation of new automatic fabricating equipment.

TO MODERNIZE ROD MILL AT BUFFALO, N. Y., PLANT

▲ A contract to modernize a 16-stand rod mill in the Buffalo, N. Y. plant of the Wickwire Spencer Division of the Colorado Fuel and Iron Corp. has been awarded to United Engineering and Foundry Co. The rebuilt mill will be a 20-stand installation rolling three strands with a maximum delivery speed of 4400 fpm. United will supply new roll stands; complete new drive mechanism and coiling equipment.

PITTSBURGH FIRMS COMBINE OPERATIONS

▲ Plans to combine manufacturing operations were disclosed by Salem-Brosius, Inc., and Phillips Corp., both of Pittsburgh. While completely maintaining their separate corporate identities, they have agreed to pool production facilities.

Salem-Brosius will lease 45,000 sq ft of space in the Phillips factory building which is adjacent to the Salem-Brosius plant in suburban Carnegie. Salem-Brosius will use this portion of the Phillips plant, plus its own building, to carry on manufacturing activities for both companies. Salem-Brosius will handle Phillips production work on a contract basis, using

its present facilities plus equipment to be purchased from Phillips.

Joint production is predicted by September 1 and officials of both firms expect to reach full scale pool operations by October 1.

An unusual feature of the combined manufacturing operation is that Salem-Brosius will buy Phillips manufacturing equipment through a long-term sales agreement in which the rate of pay depends on the number of hours the machinery is actually used.

MESTA WILL INSTALL INLAND ROLLING MILL

▲A contract covering the design and manufacture of a rolling mill installation at the Indiana Harbor Works of Inland Steel Co. has been awarded to the Mesta Machine Co.

The contract includes alterations and improvements to existing equipment, as well as a new reversing universal and edging mill stand, a universal finishing mill stand, and tables, gag press, straightener, saws, transfers, and finishing equipment. This installation will provide Inland with rolling capacity to produce up to 325,000 tons annually of wide flange steel beams in sizes ranging from 8 in. to 24 in.

Mesta will be responsible for the complete layout; will make all the details required for the construction of the foundations and electrical system; and will supervise the work of installation in the field.

FORD AWARDS CONTRACT FOR FURNACE RELINING

▲ Ford Motor Co. has awarded a contract to Standard Boiler & Plate Iron Co. of Pittsburgh, covering the relining of blast furnace "B" at the River Rouge plant.

INSTALLS PRECIPITATORS AT COLUMBIA-GENEVA

▲ Two electrostatic precipitators are now being installed at the Columbia-Geneva Steel Division, U. S. Steel Corp., Geneva, Utah. According to Research Corp., manufacturers of the equipment, the precipitators will clean gases from two iron ore sintering machines. Gas cleaning capacity is 280,000 cfm.

AUTOMATIZING?

PRATT & WHITNEY

has the right gage

. . . to do the job better

. . . at the lowest possible cost

IN AUTOMATION, the first vital link in the automatic control chain is the Continuous Gage. But no single gage type is right for all needs. Only Pratt & Whitney . . . offering a *complete line* of Continuous Gages . . . is in a position to recommend and furnish the *one* gage type *exactly right* for *your* specific job requirements! P&W Continuous Gages include:

NON-CONTACTING *(Radiation)*

X-RAY GAGES

. . . for strip and foil. Simple to install and maintain. Stability is excellent, unaffected by voltage fluctuations. RANGES: Steel — .001" to .075"; Foil — 0" to .010". FULL SCALE MAGNIFICATION: ± .00025" on Foil; ± .001" on thicker strip.

BETA RAY GAGES

. . . check a wide variety of metals, alloys and non-metallics. Especially well adapted to gaging coated materials when used with a Proportionate Syncronizer. RANGES: Steel — .030" maximum; Other Materials — to 200 ounces per square yard. FULL SCALE MAGNIFICATIONS: to suit job requirements.

CONTACTING *(Electrolimit)*

MODELS D AND 10-A

. . . continuously indicate thickness variations to .0001" in strip steel and other metals. Combine precise mechanical gaging with electrical magnification. RANGES: to 3/8" thickness by .0001" increments. MAGNIFICATIONS: to suit job requirements.

MODEL B WIDTH GAGE

. . . for narrow strip and flat wire width or round wire diameter. Also used for precision automatic control of coating thicknesses. RANGE: 0" to 2" by .0001" increments. FULL SCALE MAGNIFICATION: ± .005", or to suit job.

CALL IN THE PRATT & WHITNEY SPECIALIST NOW . . . his broad experience can help you make the most of all the advantages AUTOMATION offers you.

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First Choice for Accuracy

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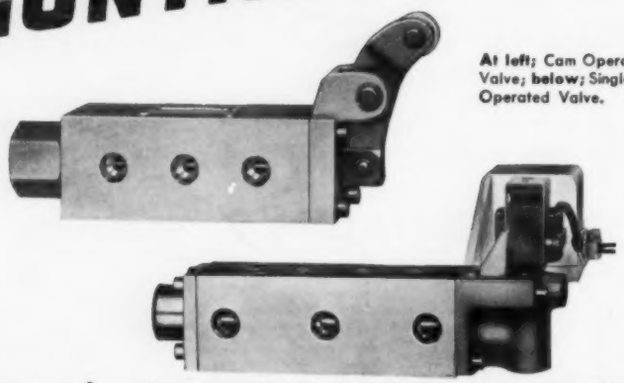
MACHINE TOOLS • CUTTING TOOLS • GAGES

SELECT

Quick-As-Wink®

AIR AND HYDRAULIC

CONTROL VALVES



At left; Cam Operated Type "O" Valve; below; Single Solenoid Pilot Operated Valve.

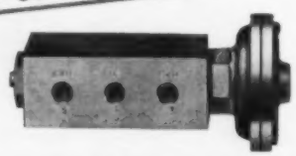
They're designed to give you the fast dependable trouble-free action you need

for single or sequence machine movements

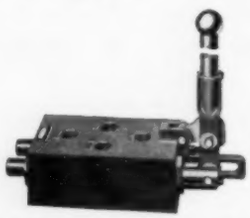
• Those successive and inter-related machine operations — that speed manufacture and cut costs — can only be as successful as the air and hydraulic valves that control the operations. Specify Quick-As-Wink Control Valves.

Positive and fast acting, Quick-As-Wink valves are designed and built to meet the most exacting requirements. They will deliver dependable and precision performance month after month, and year after year. Many superintendents and foremen have found that there is nothing better than a Quick-As-Wink valve. Can you afford to gamble with less? Get full details. Write for Bulletin No. 531 today!

Ask us also about . . .



DIAPHRAGM OPERATED "O-TYPE" VALVE, diaphragm can be actuated with instrument air as low as 12 to 15 psi.

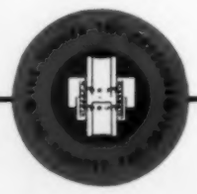


LEVER OPERATED HYDRAULIC VALVE suited for water or hydraulic oils up to 5000 psi. 2-way, 3-way and 4-way actions.

Quick-As-Wink

AIR AND HYDRAULIC

Control Valves



Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1927 East Pershing St., Salem, Ohio

This is the second recent application of Cottrell equipment to sintering machines. Three precipitators for this purpose are in use at the Tennessee Coal & Iron Division, U. S. Steel Corp., Wenonah, Ala. These are rated at 150,000 cfm each. Efficiency of the units, in series with mechanical collectors, exceeds 95 per cent.

The Utah works of Columbia-Geneva is also installing eight precipitators to clean gases from ten open-hearth furnaces.

GENERAL AMERICAN ACQUIRES FULLER CO.

▲ The execution of a contract for the acquisition of the Fuller Co. of Catasauqua, Pa., was announced by General American Transportation Corp. The transfer includes Fuller Co.'s wholly-owned subsidiaries, Hershey Machine & Foundry Co., of Manheim, Pa., and Separation Process Co. of Catasauqua.

William J. Stebler, president of General American, in making the announcement disclosed that the acquisition will be effected by the exchange of General American common stock having a market value in excess of $9,000,000 for all of the outstanding stock of the Fuller Co.

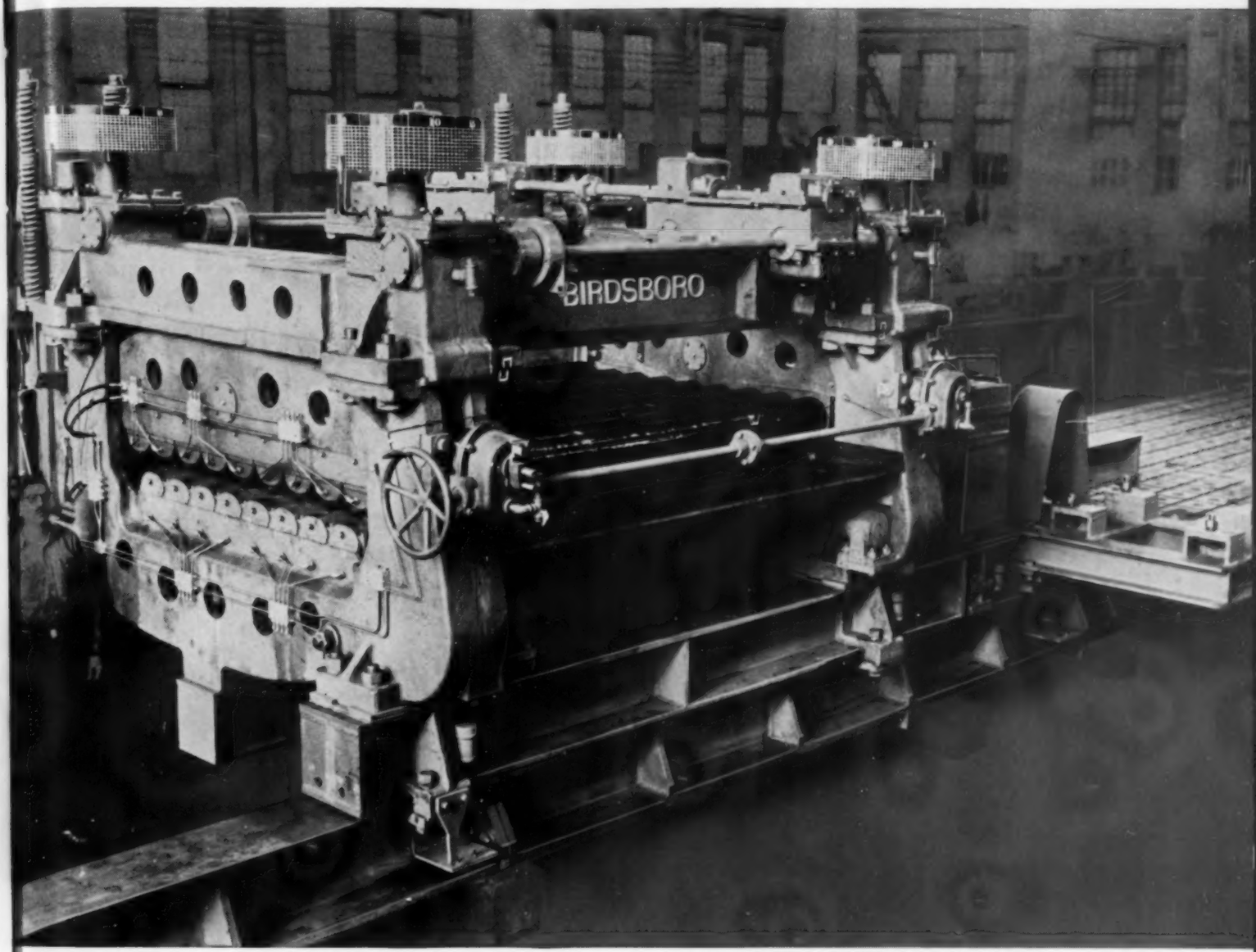
P&H MARKS 15,000TH HEAVY-DUTY CRANE

▲ Officials from Harnischfeger Corp. and A. O. Smith Corp. met at a ceremony June 11, marking the 15,000th heavy-duty P&H crane built by Harnischfeger. Starting with crane No. 1 in 1887 when P&H built the first three-motor overhead traveling crane, the number of heavy-duty cranes to be produced each year by this manufacturer has steadily increased. Cranes of all types built by P&H actually exceed 18,000.

Representatives of A. O. Smith Corp., Milwaukee, were presented with a bronze plaque for mounting on the 15,000th P&H crane installed in A. O. Smith's pipe plant in Houston, Tex. Presenting the award was Mr. Henry Harnischfeger, executive vice president. The 15,000th P&H crane has an 80-foot span and is of 20 tons' capacity. It has P&H Magnetorque ac crane control.

(*Please turn to page 256*)

Keeps leveling costs *on the level*...



Leveling machine for hot, mild steel ¼" to ⅝" x 100" wide.

BIRDSBORO Plate Leveler

Designers and Builders of:

STEEL MILL MACHINERY
HYDRAULIC PRESSES
CRUSHING MACHINERY
SPECIAL MACHINERY
STEEL CASTINGS
Weldments "CAST-WELD" Design
ROLLS: Steel, Alloy Iron, Alloy Steel

If you think that high costs are a "necessary evil" on your leveling jobs, investigate the cost-saving advantages of smooth running, maintenance-free BIRDSBORO precision levelers.

There's a BIRDSBORO Leveling Machine designed to give you maximum results at minimum cost, whether your operations include leveling of hot or cold, heavy or light plate. BIRDSBORO engineers also have the diversified experience and know-how to design, engineer and build special levelers to meet your specific requirements.

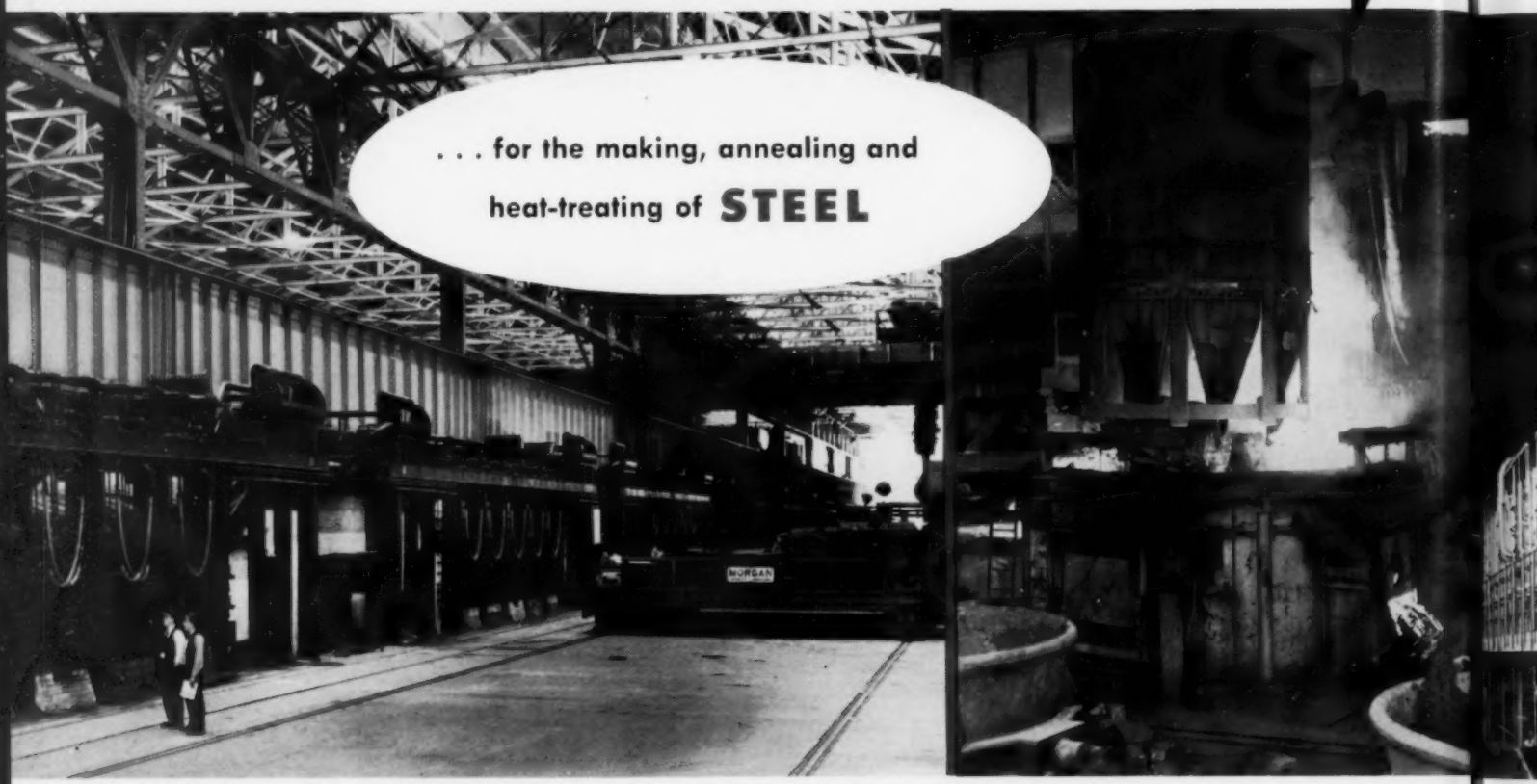
Put BIRDSBORO engineers to work on your application . . . and keep leveling costs "on the level".

MM-31-54

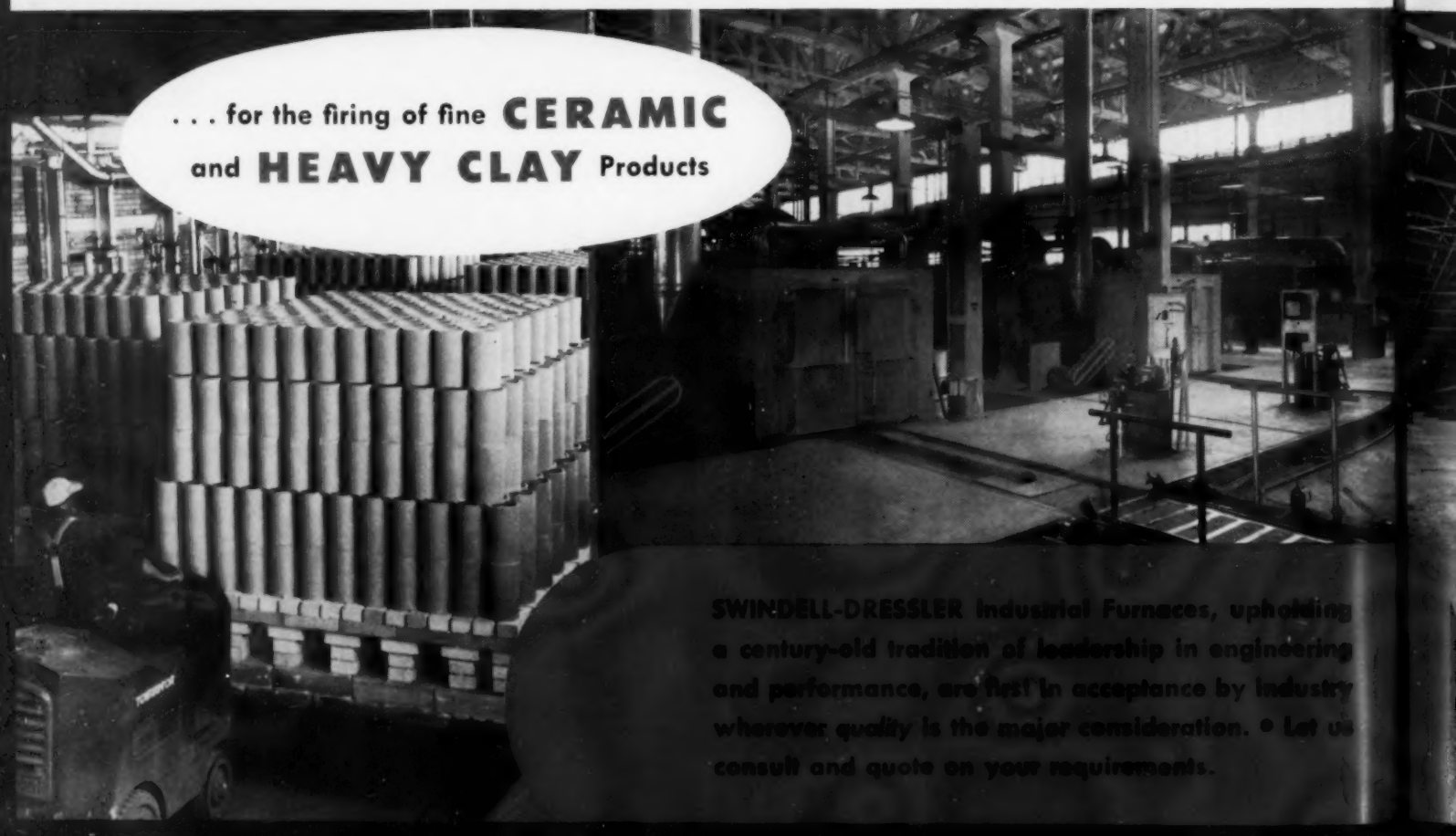
BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., BIRDSBORO, PENNA. Offices in Birdsboro, Pa. and Pittsburgh, Pa.

SWINDELL-DRESSLER



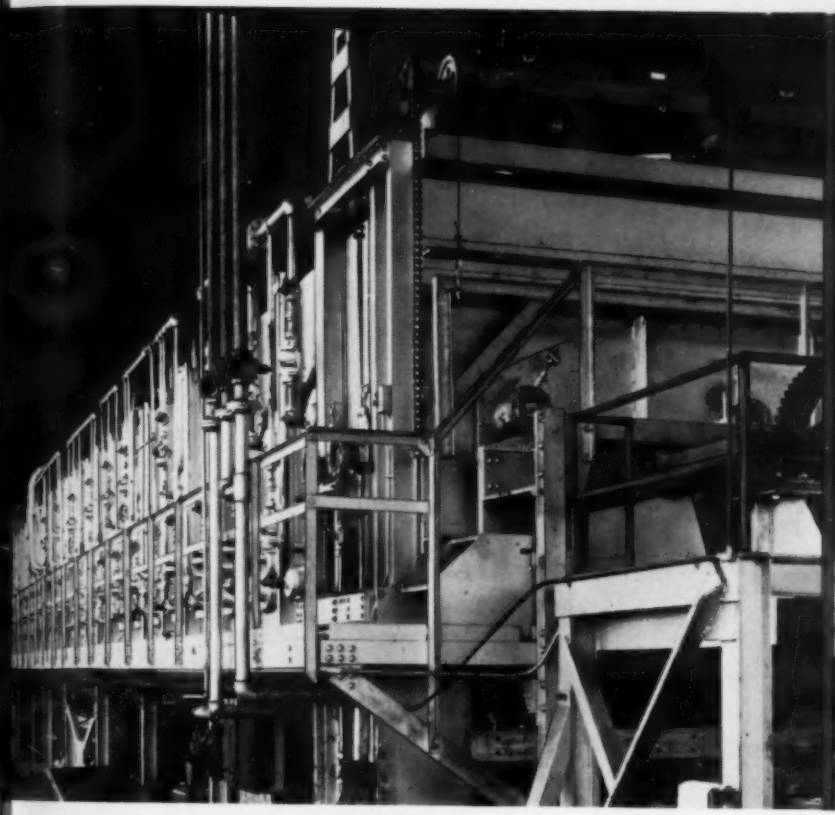
. . . for the making, annealing and heat-treating of **STEEL**

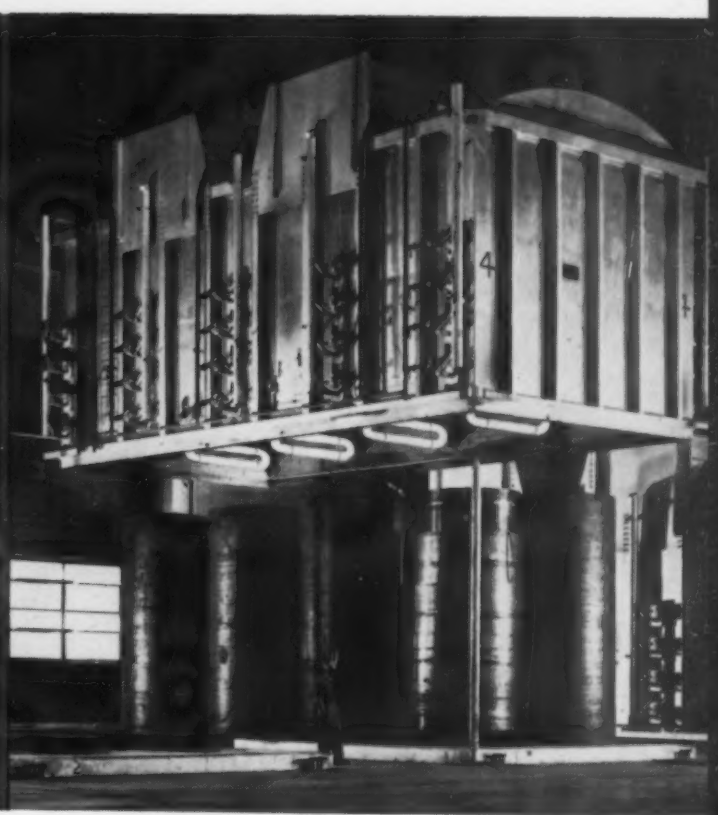


. . . for the firing of fine **CERAMIC** and **HEAVY CLAY** Products

SWINDELL-DRESSLER Industrial Furnaces, upholding a century-old tradition of leadership in engineering and performance, are first in acceptance by industry wherever quality is the major consideration. • Let us consult and quote on your requirements.

Modern INDUSTRIAL FURNACES





. . . for the heat treatment
of **ALUMINUM**

SWINDELL-DRESSLER
Corporation
Designers and Builders of Modern Industrial Furnaces
PITTSBURGH 30, PA.

(*Continued from page 252*)

CALL NUCLEAR REACTOR "STRIDE INTO UNKNOWN"

▲ The nuclear reactor, which will create heat and produce the steam for Duquesne Light Co.'s atomic power plant in Shippingport, Pa., will be unlike any electric utility steam plant ever built. Its designers call it "a long stride into the unknown."

There will be no tall chimneys and no smoke. No large building will house furnaces and boilers and no great piles of coal will be found nearby. In fact, the casual observer will see no steam plant at all. The steam-producing nuclear reactor will be underground inside a shell of steel within walls of concrete.

As ground was broken at Shippingport on Labor Day for the nation's first atomic powered electric generating station, Westinghouse Electric Corp. officials described the unprecedented nuclear reactor which their firm's Atomic Power Division has designed and is building under contract to the Atomic Energy Commission.

Not only will it be unlike any other electric utility steam plant, it will be unlike any other power reactor ever built. As explained by Charles H. Weaver, manager of the Westinghouse Atomic Power Division, here's how the atomic steam plant will work:

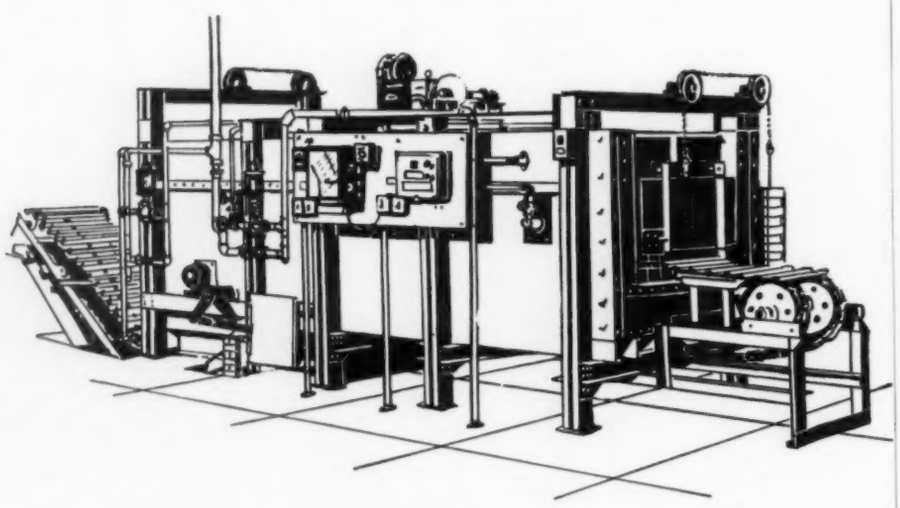
The "core" of the reactor where the heat is produced will be made up of a geometrical pattern of uranium fuel elements—about 10 tons of uranium in all. These fuel elements will be fitted tightly together into a cylindrical shape about 6 ft in diameter and 7½ ft high. This core will be contained inside a steel vessel about 9 ft inside diameter and more than 25 ft high—big enough to accommodate larger cores in the future.

Within this core will occur the splitting or "fissioning" of uranium atoms—a process which produces great energy in the form of heat. This heat will be transferred from the core to four boiler-like heat exchangers by means of water under high pressure. This is where the reactor gets its name "pressurized water reactor" or, for short, PWR.

Four 18-in. diameter pipes, made of stainless steel, will penetrate the wall of the core vessel. Through these pipes will be pumped purified water under a pressure of about 2000 lb per sq in. When this water passes through the red hot uranium core it is heated to about 525 degrees F—but does not boil because it is under pressure.

From the core, the hot water is circulated in four "primary loops" to the four heat exchangers inside of which it passes through a series of stainless steel tubes. At the same time, a second supply of water will be fed into each heat exchanger and flow upward over the outer surface of the hot tubes. Because this second supply of water is under a lower pressure, it turns to steam. This steam, after being dried by passing through conventional steam separators, then is piped into the steam turbine located above ground in Duquesne Light Co.'s electric generating station. The steam rotates the turbine which, in turn, drives the generator that will produce a minimum of 60,000 kw of electricity.

This entire primary plant will be enclosed in a steel container to retain any radioactive materials which



CHAIN CONVEYOR

R-S Chain Conveyor Furnaces are continuous furnaces through which the work is passed on endless chains or rolled or pulled through by fingers attached to the chains. They are furnished as direct-fired furnaces for temperature ranges from 1000° to 1800° F. or as forced convection units for ranges from 600° to 1400° F., using oil, gas or electricity.

R-S
QUALITY FURNACES SINCE 1908

R-S FURNACE TYPES

Hi-Head ● Batch ● Rotary Hearth ● Continuous Belt Conveyor ● Continuous Chain ● Continuous Pusher ● Continuous Pusher Tray ● Pit ● Continuous Roller Hearth ● Car Hearth

might escape as the result of an accident, however improbable. The whole steam plant will be located in a concrete structure underground.

Although this first central station type reactor is not expected to be economically "competitive" with conventional coal-burning plants, its designers have kept their eye on costs in recognition that the goal ultimately is to produce an economical atomic power plant.

"Enriched uranium is expensive so we will use uranium that is only slightly enriched — that is, uranium containing a slightly higher amount of the 235 isotope than natural uranium as mined from the earth," said Mr. Weaver. "Instead of using heavy water which is expensive we will use ordinary water. Since fuel reprocessing is expensive we will try to make each core last as long as possible and will deliberately burn the plutonium that is generated through the reactor operation. Other design features also will make for more economical operations. All of these features will make the PWR unlike any (power) reactor ever built before. They constitute a long stride into the unknown—steps that some day will lead to a power reactor that will be economically competitive."

Westinghouse was assigned the responsibility for the development and design of the PWR on July 1, 1953. Work has been under way since that date at the AEC's Bettis plant near Pittsburgh, which is the headquarters of the Westinghouse Atomic Power Division.

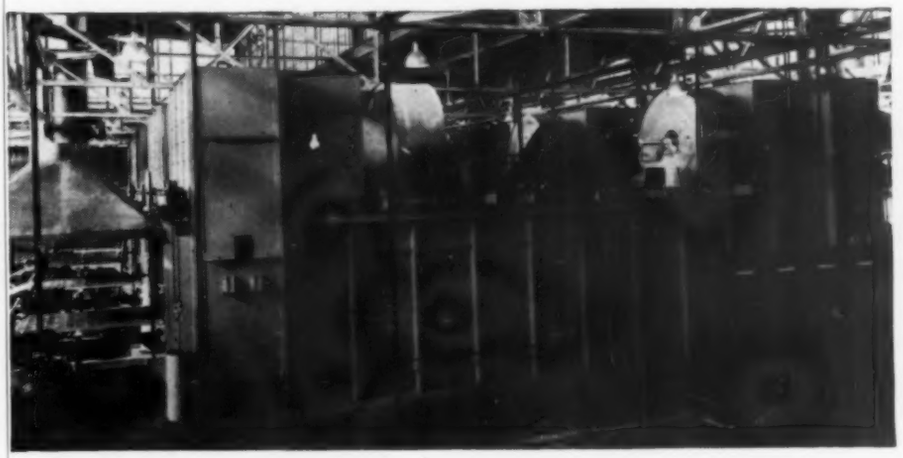
The company also has built a plant near Cheswick, Pa., in the Pittsburgh district, for its atomic equipment department. This plant is building the type of "canned motor pumps" which were developed for pumping the radioactive water through the primary loops of the submarine reactors and which will play a similar role in the PWR.

INCREASED USE OF ALLOY STEEL TUBING PREDICTED

▲ Annual shipments of alloy steel tubing should reach a total of 1,000,000 tons by 1960, if the present rate increase continues, according to Edward A. Livingstone, vice president in charge of the tubular products division of the Babcock & Wilcox Co. Noting that shipments increased from 276,217 tons in 1946 to 576,068 tons in 1953, Mr. Livingstone predicted that this upward trend would continue in the next decade at an even higher rate of increase because technological advancements are constantly creating new uses for alloy steel tubing.

"To help meet this increasing demand, our division has recently completed a four-year expansion program which has more than doubled our steel-making facilities and provided a capacity of about 230,000 ingot tons per year," Mr. Livingstone said.

The company has added two electric arc furnaces—one having a capacity of 75 tons and the other, 50 tons—making a total of four now in service. One three-hole and one four-hole battery of soaking pits were included in the program to provide for the increased tonnage. A 1500-ton forging press was also installed to provide additional forging capacity of 120,000 tons per year.



R-S Chain Conveyor Type Furnace used for heating metals for drawing. Gas-fired, convection type. Maximum temperature 1400° F. Capacity 5800 pounds per hour. Size — 36′ long, 5′ 3″ wide, and 18″ high.

FURNACES BY R-S

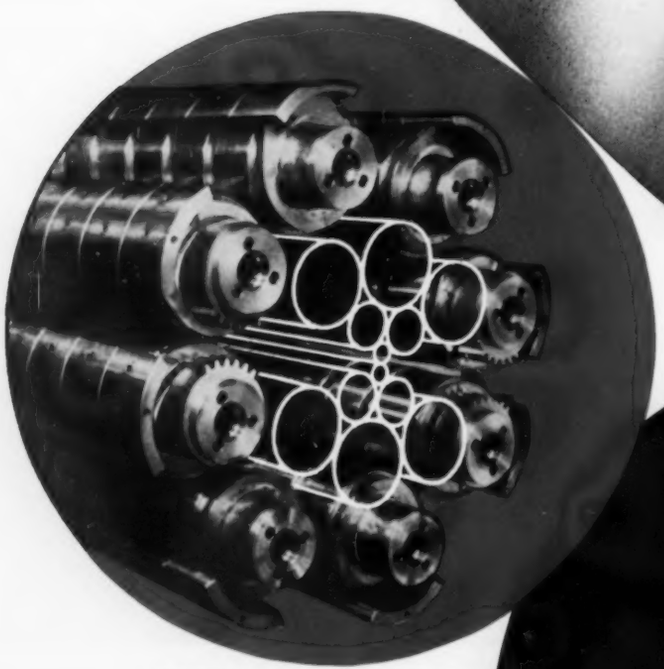
They are used to heat for forming, heat treating, annealing, stress relieving, and drawing in the ferrous industries, and for heating billets for extrusion and forging in aluminum plants. One important use is for the continuous annealing of centrifugally cast iron pipe. Write today for Bulletin No. 200 describing R-S Furnaces for metal heating and heat treatment.

R-S FURNACE CORP.
4555 GERMANTOWN AVENUE
PHILADELPHIA 44, PENNSYLVANIA
A SUBSIDIARY OF
HARDINGE COMPANY, INC.

R-S
QUALITY FURNACES SINCE 1908

This 80" SENDZIMIR MILL

maintains precise gauge across the width and along length of strip



Phantom view of roll arrangement

This Sendzimir cold strip mill rolls 80" wide low carbon steel from hot rolled thickness to .024" with total gauge variation of .0004". Similar uniformity is being regularly obtained on Sendzimir cold strip mills rolling brass, copper, aluminum, stainless steel, silicon steel, etc.

CONSIDER THE ADVANTAGES OF THE SENDZIMIR COLD MILL

- Extreme Accuracy In Gauge, Due To Uniform Support Throughout Mill
- Elimination Of Intermediate Anneals
- Greater Reductions Per Pass
- Highest Surface Finish
- Quick And Simple Roll Changes
- Low Initial And Maintenance Costs

SENDZIMIR MILLS

ARE ENGINEERED BY

ARMZEN CO.

SALES & ENGINEERING AT WATERBURY 12, CONN. TEL. PLaza 6-4617

FOREIGN: SENDZIMIR LTD., 75 Grosvenor St, London W1, England

PROCÉDÉS SENDZIMIR S. A. R. L. 73 Blvd. Malesherbes, Paris 8, France

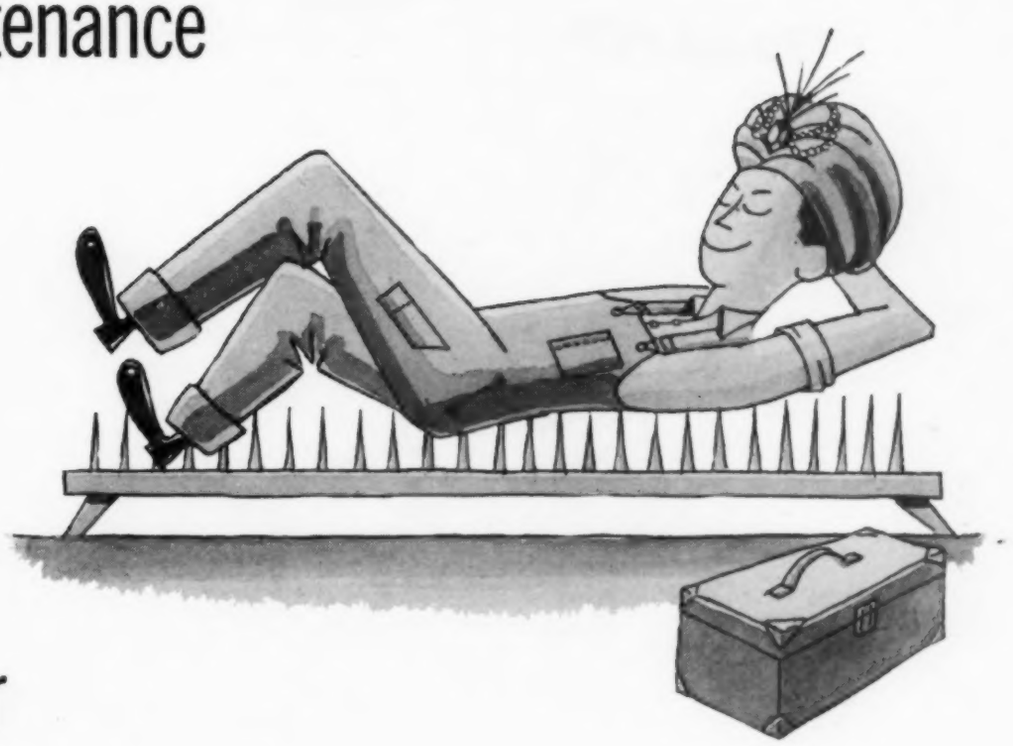
Backing Roll Support

Sendzimir Support

ALSO SENDZIMIR COLD SHEET MILLS—SENDZIMIR PLANETARY HOT STRIP MILLS

AR-4

Maintenance men rest a lot easier when the electrical installation is by



FISCHBACH AND MOORE

INCORPORATED

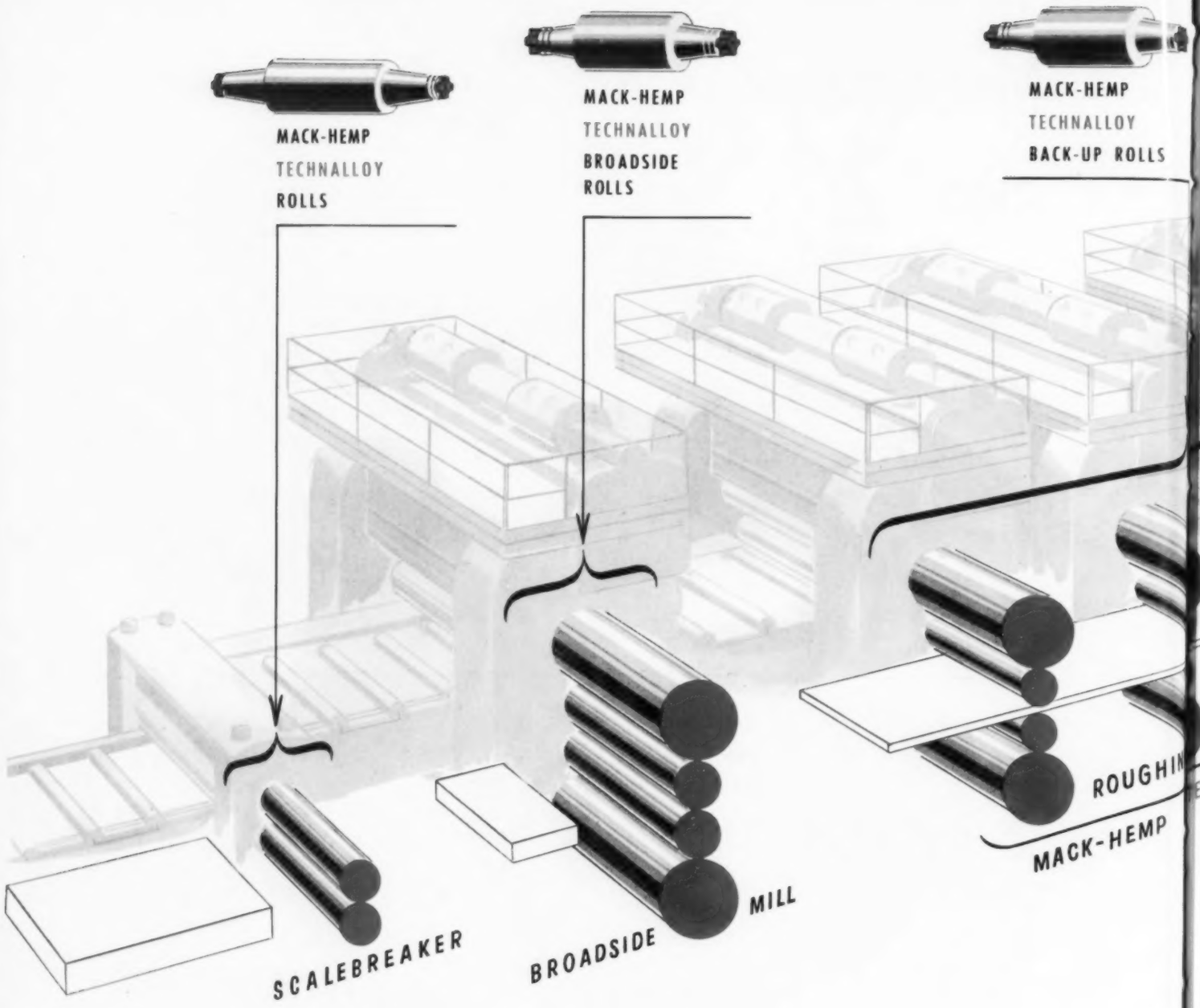
ELECTRICAL CONTRACTORS

SINCE 1918

FROM COAST TO COAST *An organization that has to its credit every conceivable type of electrical installation.*

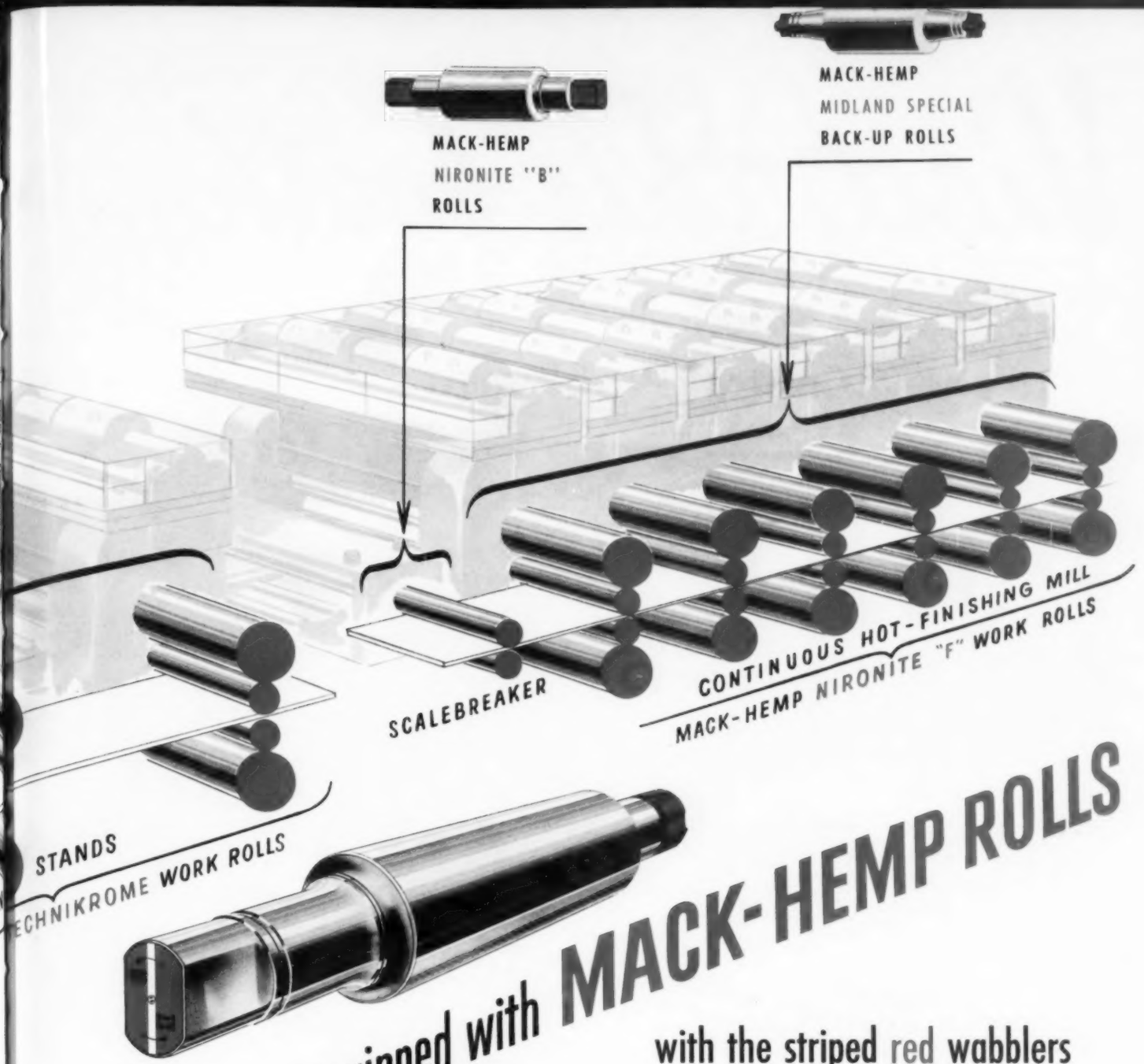
COMPLETE ORGANIZATIONS AT:

NEW YORK 17, N. Y. 226 East 41st Street	**ATLANTA, GA.** 244 Simpson Street N.W.	**DALLAS 4, TEXAS** 1717 Baylor Avenue	**HOUSTON 2, TEXAS** Bankers Mortgage Bldg.
LOS ANGELES 4, CALIF. 646 North Beachwood Drive	**SAN FRANCISCO 7, CALIF.** 383 Fourth Street	**CHICAGO 10, ILL.** 1011 North Orleans Street	**DETROIT 2, MICH.** 101 Piquette
PITTSBURGH 3, PA. 81 South 19th Street	**PHOENIX, ARIZONA** 2246 West Jackson Street	**SEATTLE 3, WASHINGTON** 3201 Fremont Avenue	**NEW ORLEANS, 19, LA.** 315 North Broad Street



hot strip mill production rolls ahead when

MACKINTOSH-HEMPHILL COMPANY
PITTSBURGH U.S.A.



all stands are equipped with MACK-HEMP ROLLS

with the striped red wabblers

For excellent production records here's a rolls recipe that's sure to work: put Technikrome work rolls in the roughing stands, special Nironite "F" rolls in intermediate stands, and regular Nironite "F" rolls in the finishing stands; back them up with Technalloy or Midland Special rolls.

The superior performance you can expect from a mill such as this where all stands are equipped with Mack-Hemp Rolls *with the Striped Red Wabblers*, reflects the perfect cooperation which your roll designers and mill operators have given Mack-Hemp metallurgists, plus Mack-Hemp's many years of roll-making experience.

Look into the service records of Mack-Hemp Striped Red Wabbler rolls in the mills where they are installed and you'll be convinced that it always pays to keep an eye on what's new and different at Mack-Hemp.

MACKINTOSH-HEMPHILL COMPANY

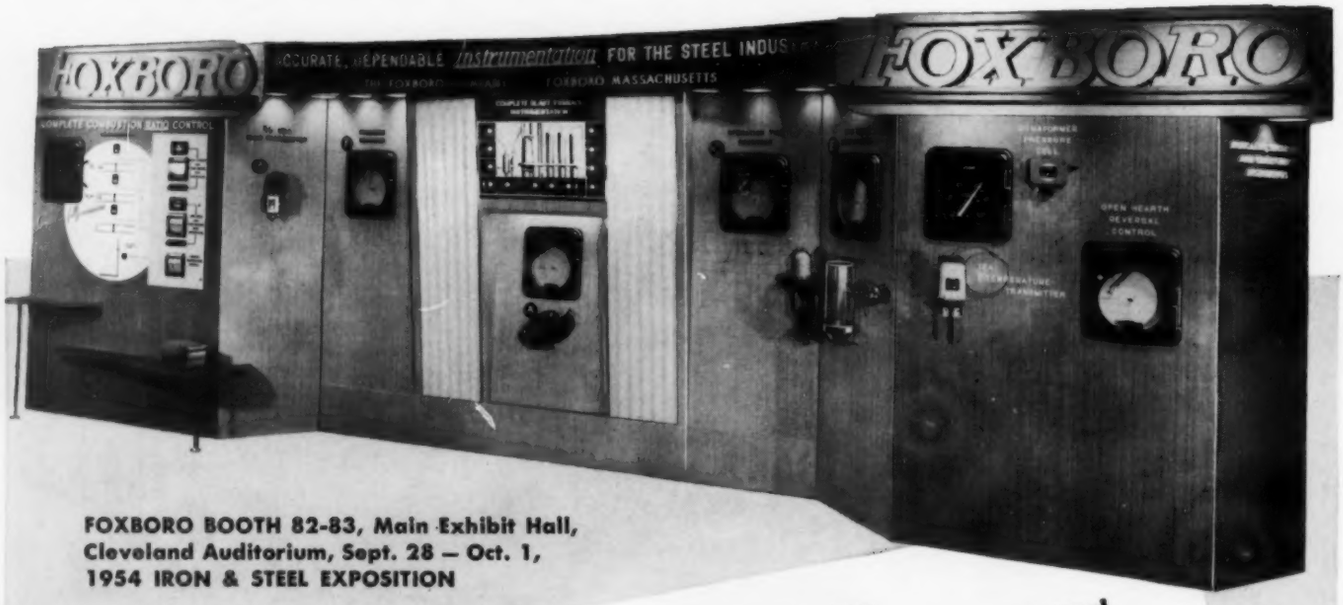
PITTSBURGH AND MIDLAND, PA.

Makers of the Rolls with the Striped Red Wabblers

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: all types of cast mill rolls . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . Mackintosh-Hemphill rotary straighteners—electronically controlled contouring lathes—screw feed roll turning lathes—heavy duty engine lathes . . . shears . . . end-thrust bearings . . . steel and special alloy castings . . . reversing hot strip mills . . . Y-type cold strip mills.

Visit this booth...

for Latest Solutions to these Control Problems...



FOXBORO BOOTH 82-83, Main Exhibit Hall, Cleveland Auditorium, Sept. 28 – Oct. 1, 1954 IRON & STEEL EXPOSITION

BLAST FURNACE
Inwall Temperature Recording
Hot Blast Temperature Control
Air Blast Moisture Control
Primary Gas Washer Temperature Recording

SOAKING PITS
Complete Combustion Ratio Control

OPEN HEARTH
Fully Automatic Reversal Control by checker temperature difference

HEAT TREATING
Gas Atmosphere Richness Control based on accurate dew point measurement

PICKLING
Automatic Tank Temperature Control

WASTE DISPOSAL
Fully Automatic Control Instrumentation for neutralization of all steel mill waste fluids

STOCK STORAGE
Automatic Dew Point Control to prevent rust, discoloration

THE FOXBORO COMPANY, 589 NEPONSET AVE., FOXBORO, MASS., U.S.A.

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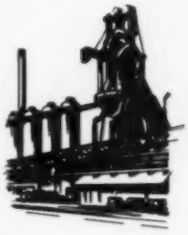
INSTRUMENTATION FOR STEEL MILLS



Industrial Cut Gears

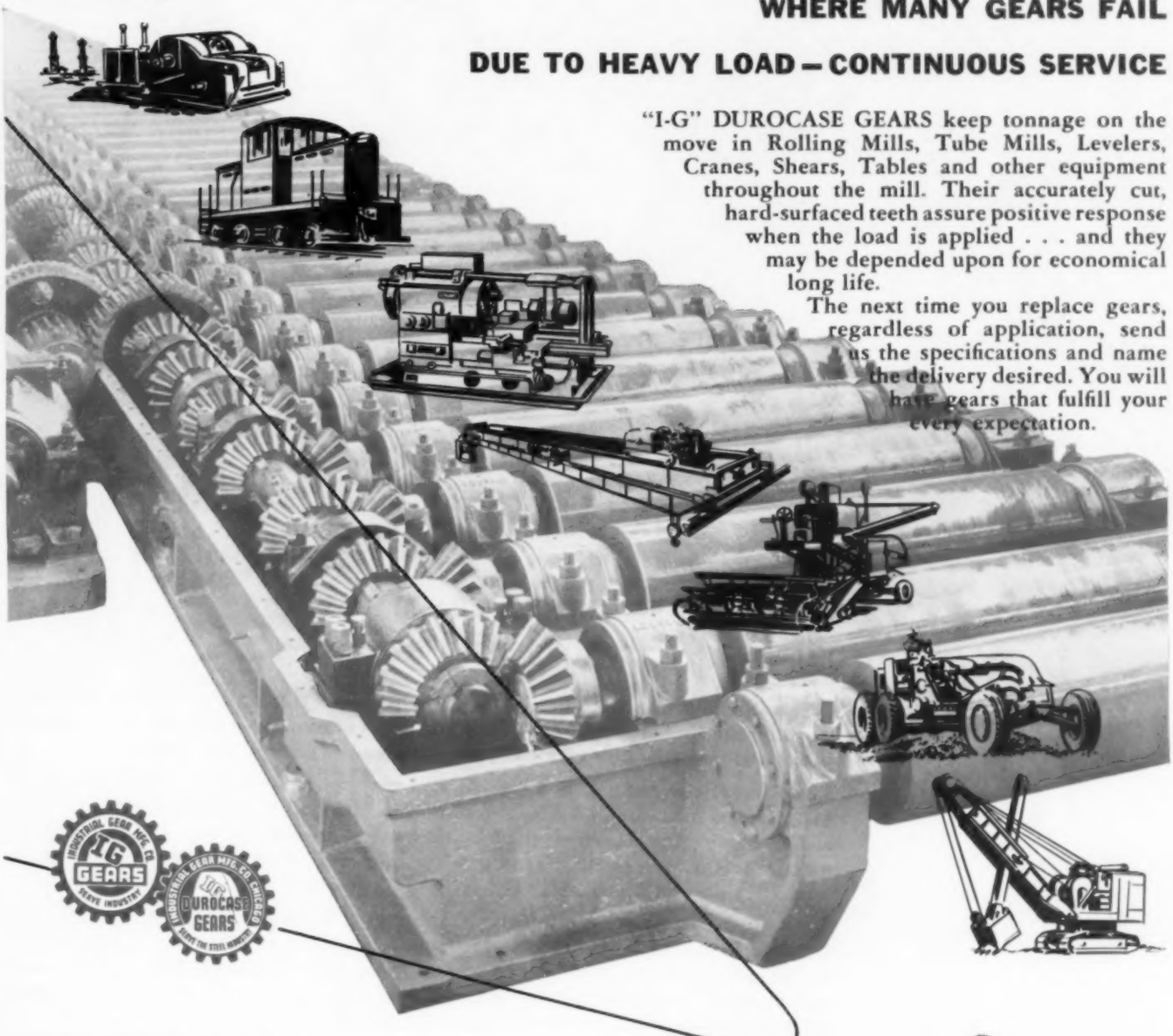
FOR THE TOUGH JOBS

WHERE MANY GEARS FAIL

DUE TO HEAVY LOAD—CONTINUOUS SERVICE

"I-G" DUROCASE GEARS keep tonnage on the move in Rolling Mills, Tube Mills, Levelers, Cranes, Shears, Tables and other equipment throughout the mill. Their accurately cut, hard-surfaced teeth assure positive response when the load is applied . . . and they may be depended upon for economical long life.

The next time you replace gears, regardless of application, send us the specifications and name the delivery desired. You will have gears that fulfill your every expectation.



Our plant, devoted exclusively to gear and sprocket cutting, can be visited pictorially through Bulletin No. 152-A. Write for your copy—and see how well equipped we are to handle your needs.

MEMBER OF AGMA

Industrial Gear Mfg. Co.

4527 W. VAN BUREN ST.
CHICAGO 24, ILLINOIS

ROLLS HARDENED
7 to 12 times faster

SELAS RADIANT PRECISION HEAT SPEEDS
HARDENING . . . ASSURES UNIFORM HARDNESS

Roll hardening has been speeded up 7 to 12 times faster than ordinary methods with the new Selas Radiant Heat Roll Furnace. Harmful scale eliminated. A uniform pattern of hardenability attained. The shoulders of the roll not affected.

Lined with Selas radiant heat burners this new gas furnace precisely patterns heat and hardens rolls up to 60 inches in diameter. Rolls are rotated during the heating and quenching cycles. When the heating cycle is finished furnace halves are easily rolled back on tracks . . . roll is quickly quenched. Result . . . no harmful scale formed . . . no soft spots.

Selas engineers working throughout the metal industry have speeded up heat treating, metal fusion, brazing, forging and other operations by scientifically applying radiant gas heat. Let them help you speed up your production, reduce costs and improve quality with Selas heat processing equipment . . . engineered to your production line. Write for booklet on radiant heat.

SELAS

CORPORATION OF AMERICA • PHILADELPHIA 34, PENNSYLVANIA

Heat Processing Engineers for Industry • Development • Design • Manufacture

PRODUCTION CONTINUITY at Detroit Steel's new Portsmouth, Ohio, plant is aided by a G-E engineered power system. Primarily designed for reliability of service and for future expanded capacity, it provides power, for example to these G-E tandem cold strip mill main drives which total 11,500-hp. New facilities provide five times the former finished-product output.

G-E engineering services help Detroit Steel to double ingot capacity at Portsmouth, Ohio

Detroit Steel's sixty million dollar expansion at Portsmouth, Ohio is now complete. The project, an up-to-the-minute example of modern electrification, includes: blast furnaces; open hearth furnaces; soaking pits; blooming and slabbing mill; hot strip mill; pickle line; tandem cold strip mill; and temper mill and processing lines: co-ordinated electrical systems are a vital part of these facilities.

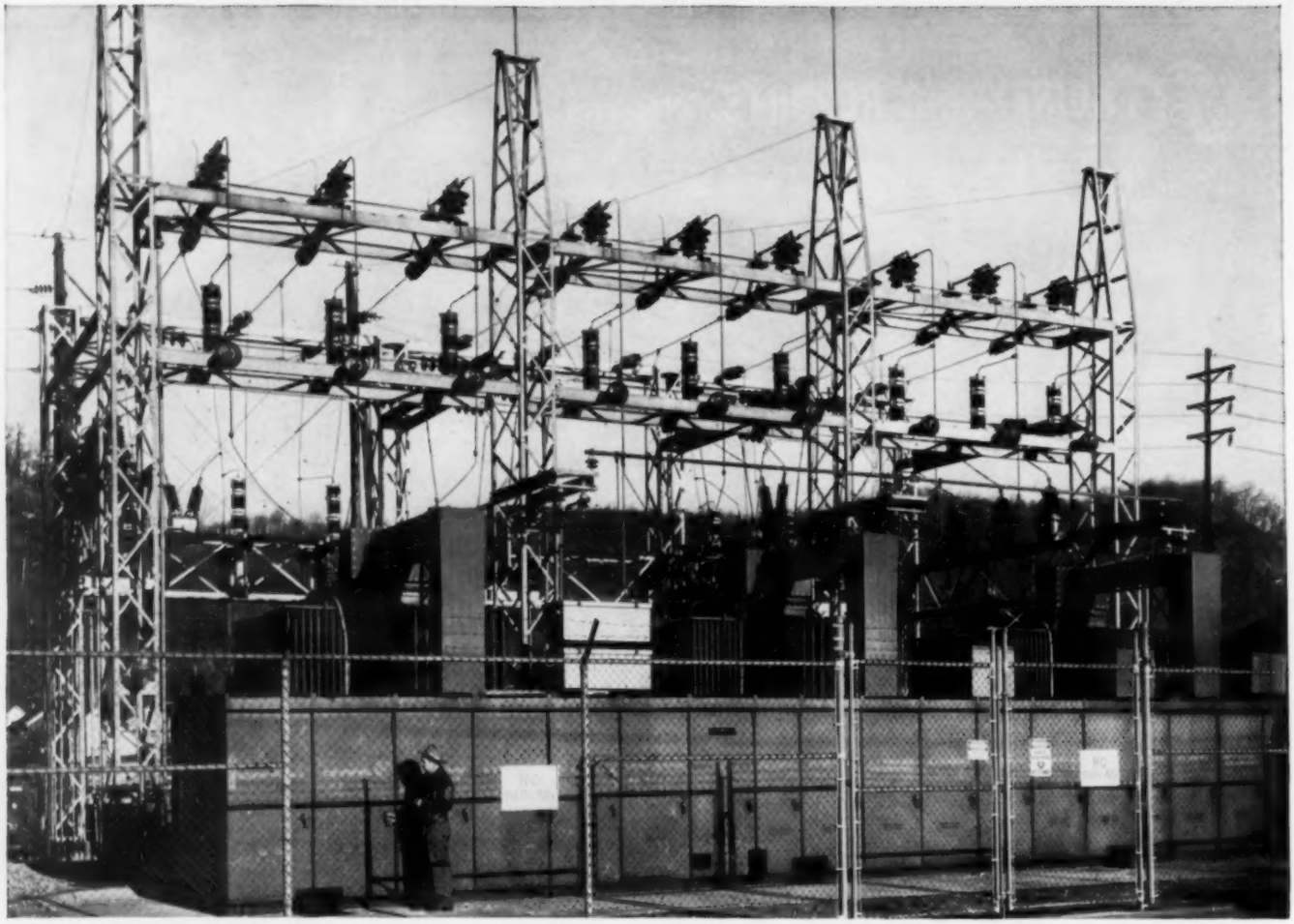
They were engineered and equipped almost 100% by General Electric working closely with such companies as Wellman Engineering Co., John Mohr and Sons, Loftus Engineering Corporation, United Engineering and Foundry Company, Pittsburgh Engineering and Machine Company, Morgan Engineering Company, Stamco, Wean Engineering Company, and Patterson-Emerson-Comstock, Inc.

In the planning stages, G-E application engineers helped define power system requirements. As work progressed, G-E project co-ordinators carefully timed electric equipment deliveries to conform to construction schedules. Finally, G-E field engineers helped supervise the equipment's installation to speed start-up.

The new facilities enable Detroit Steel to double ingot capacity, provide five times the former finished-product output. Practically automatic, the mill employs many outstanding examples of modern power distribution techniques that provide reliability for continuous output.

See Power Distribution Story

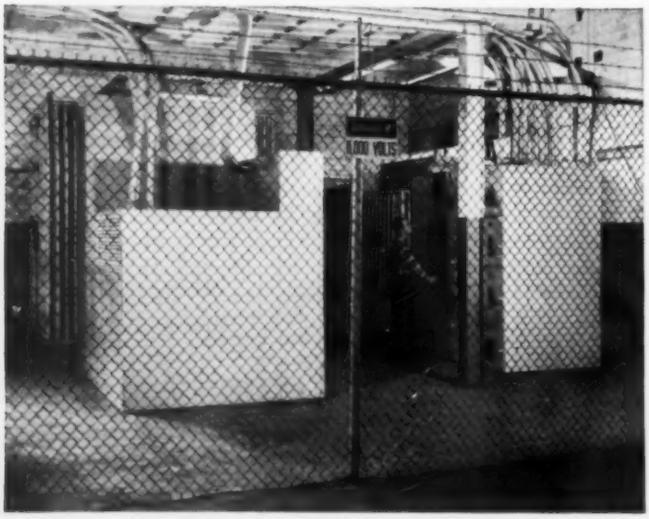
GENERAL ELECTRIC



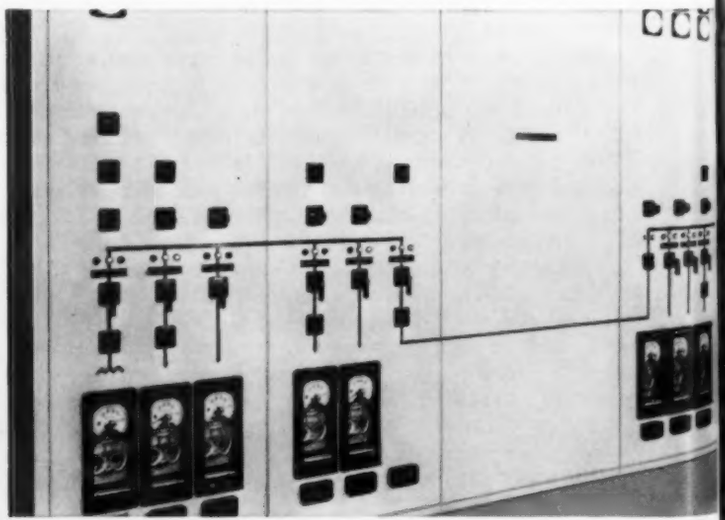
G-E PACKAGED SUBSTATION combines all electric equipment required between incoming high voltage lines and load feeder circuits. Here, all purchased power is brought into system at 34.5 kv and distributed at 11 kv to each major mill or furnace.

Engineered by General Electric for Detroit Steel . . . .

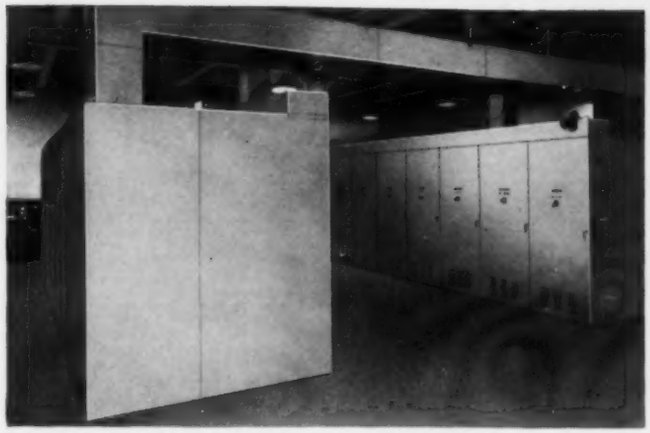
New power distribution system designed for



FLEXIBLE G-E INTERLOCKED ARMOR CABLE was used to advantage at these G-E unit substations at the Portsmouth plant. They needed no conduit, cut installation time and costs.



CENTRALIZED CONTROL of power system is provided in this G-E duplex panel. Indicators automatically notify load dispatcher of any trouble.



FACTORY ASSEMBLED, G-E metal-clad switchgear helps protect equipment and personnel, provides space-saving compactness. Circuit breakers are easily removed for maintenance.

UNIFORM VOLTAGE of power distribution system is maintained with aid of this G-E power factor and reactive kva regulator associated with tandem cold strip mill.

PRACTICALLY 100% G-E DRIVES were specified also for operating machinery throughout the plant, including, for example, the 350-cubic foot skip on this blast furnace.

reliability, easy operation, future expansion

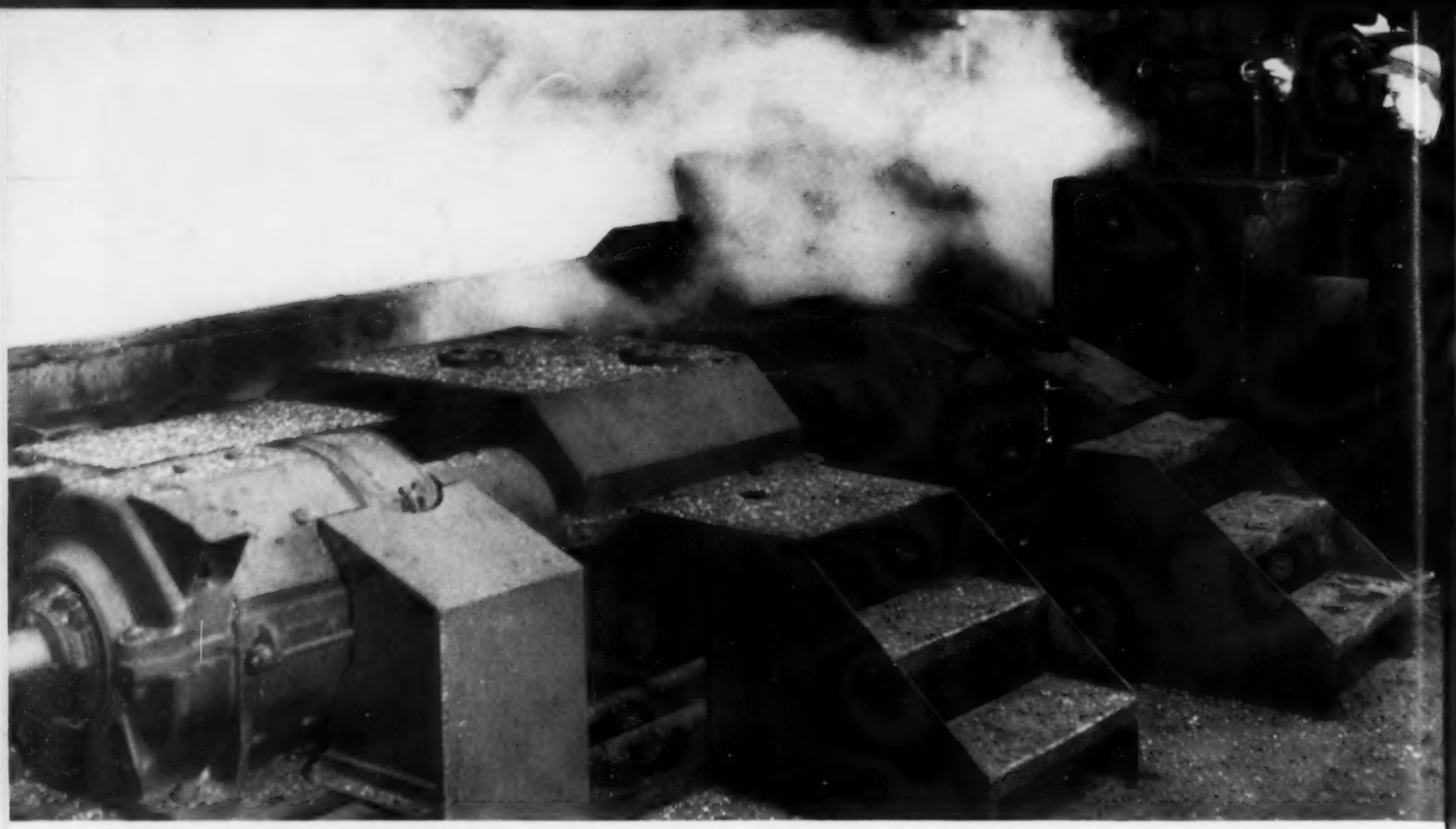
At Detroit Steel's new plant, complete loss of power would cost thousands of dollars an hour in lost wages and production alone. Therefore, General Electric helped design a reliable power system to match capacity, utilizing modern system techniques and equipment.

Close co-operation by all resulted in a more reliable, yet easily operated system, adequate for its job today and ready for future growth.

G-E engineering services are available to *you,* too—in modernizing your electrical systems to achieve higher mill speeds, increased tonnage output, lower operating costs. Contact your G-E Apparatus Sales representative early in your project planning stage. General Electric Company, Schenectady 5, N. Y. 659-103

Engineered Electrical Systems for Steel Mills

GENERAL ELECTRIC



VERSATILE MD-600 ARMORED MOTORS are shown here driving the roughing mill table. Ruggedly constructed, they are designed to withstand severe shocks, temperatures and reversing conditions. **Write for bulletin GEA-4654C.**

Specified for Detroit Steel . . .

G-E Armored motors take toughest steel-mill jobs — and last longer

MDY RUNOUT TABLE DC MOTORS, better protected against spray, dirt and grease, are easily maintained—last longer. **Write for bulletin GEA-5964.**

General Electric MD-600 armored motors and MDY runout table motors are natural choices in the electrical system for Detroit Steel's Portsmouth, Ohio plant expansion. Their better protection features and greater electrical capacities provide the reliability needed for continuous output. They've built a reputation as tough, dependable steel-mill performers.

MD-600 MOTORS—WELL PROTECTED by heavy cast-steel frames—operate under severe conditions. Whether a foot away from flying red-hot steel or drenched by water spray, they give dependable, low maintenance service.

MDY RUNOUT TABLE MOTORS give top performance under the severest duty cycle. They stop, start and reverse quickly, withstanding mechanical shock and water spray. Their rugged electrical systems and low maintenance features are well-known in the steel industry.

IN ANY INDUSTRY, where the job is tough, these two motors are hard to beat. For more information, contact your nearest G-E Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y. 810-2

Progress Is Our Most Important Product

GENERAL ELECTRIC

FOR STEEL-MILL APPLICATIONS, like the switching and control operations at Detroit Steel above, G-E Metal-clad switchgear stands up to heavy-duty operation with a minimum of maintenance, and gives maximum protection in case of overloads or faults.

SELF-X INSULATION is used as flame-retardant insulating barriers at all vital points in G-E magne-blast breakers, and Metal-clad switchgear.

VERTICAL-LIFT DESIGN raises or lowers breaker in 30 seconds. Vertical-lift isolates breaker—enables you to SEE disconnect.

Specified for Detroit Steel . . .

G-E Metal-clad Switchgear for protection and control

General Electric Metal-clad Switchgear best suited for heavy-duty steel-mill control and switching operations

Rough, heavy duty like that encountered in steel-mill applications is exactly the tough treatment for which G-E Metal-clad Switchgear was designed. For switching and control operations like those at Detroit Steel, G.E.'s completely enclosed pre-engineered units offer special advantages.

Vertical-lift design gives clear view of disconnected breaker, and faster-acting breaker-elevating mechanism, part of G-E vertical-lift design, raises or lowers breaker in 30 seconds.

SELF-X, General Electric's new flame-retardant insulation, gives added protection to metal-clad switchgear.

Rigid, all-welded frame withstands shipment stresses better than comparable equipment. Hinged doors make access to totally metal enclosed compartments easy. Advanced magne-blast breaker design requires a minimum of maintenance, and its simplified contact design assures far longer contact life. G.E.'s natural draft ventilation system for each switchgear unit affords optimum cooling for all components.

For details on G-E Metal-clad switchgear, call your nearest G-E Apparatus Sales representative, or write for booklet GEA-5664, to Section 511-6, General Electric Company, Schenectady 5, N. Y.

MAGNE-BLAST BREAKERS can take the heaviest duty, and because they interrupt arc magnetically in air, are more reliable, need less maintenance.

EASY INSTALLATION is the result of factory pre-assembly and shipment of large units with interconnections already made.

Progress Is Our Most Important Product

GENERAL ELECTRIC

FIVE REASONS WHY NATIONAL CARBON COMPANY ELECTRIC FURNACE ELECTRODES GIVE YOU THE MOST FOR YOUR MONEY...

ELECTRODE QUALITY . . . has a direct bearing on the quality of *your* product; in many instances, it can materially affect your *cost.* National Carbon's graphite and carbon electrodes are, and always have been, the finest quality obtainable *anywhere.* We make this statement without reservation.

NEW PRODUCT DEVELOPMENT . . . is basic in technological progress. National Carbon has *always* done the major part of this country's electrode research and development . . . a share out of all proportion even to its outstanding leadership in the production and sale of these products. This is a matter of long-standing record.

PLANT CAPACITY . . . National Carbon's ability to *produce* is at an all-time high. The five plants shown here are fully integrated for production of both carbon *and* graphite electrode products — a situation rare in the industry and in keeping with National Carbon's far-sighted planning to pace requirements of a rapidly-expanding economy. For example, plant additions in the last five years alone have more than doubled graphite electrode capacity.

EXPERIENCE . . . of National Carbon is the foundation, building blocks and cornerstone of electrode-products manufacture in this country. First with commercial production of both carbon and graphite electrodes in the early 1900's, National Carbon introduced the first of each increasingly larger electrode size from that time to the present, plus a host of successful accessory items for improved application of electrodes in the metallurgical field. Today, National Carbon is the only company producing carbon electrodes up to 45″ diameter; graphite electrodes to 35″. Even larger electrodes and other massive shapes can be made with present facilities. Inquiries are invited.

RESPONSIBILITY . . . to customers and to the industry as a whole . . . expresses itself several ways in National Carbon history. The company has consistently kept ahead of demands for both quality and size of electrode products; National Carbon research stands virtually alone in the steady march of new product development; and, in the field of *service,* National Carbon is supreme. For many years we have conducted an expanding, electrode technical-service operation, staffed by a group of electrode experts, specially trained to help you get *more for your electrode dollar.*

The terms "National" and "Acheson" are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

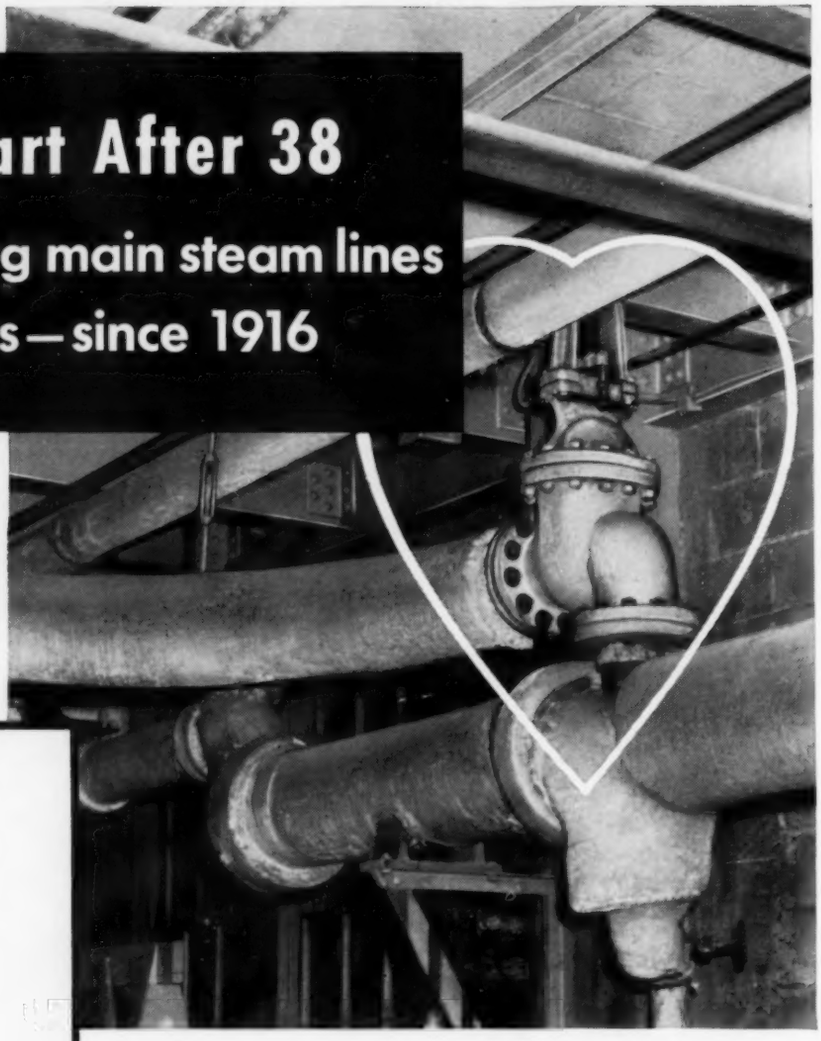
A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

IN CANADA:
Union Carbide Canada Limited, Toronto

Young at Heart After 38

Crane valves policing main steam lines with no repairs—since 1916



The Installation

In the Lehigh Portland Cement Co. plant at Oglesby, Ill. Original installation of 6- and 3-inch Crane steel valves in boiler-to-turbine steam piping. Working pressure: 160 pounds at about 475 deg. F.

Valve Service Ratings

SUITABILITY:
Hard to Beat

MAINTENANCE COST:
Not a penny for repairs

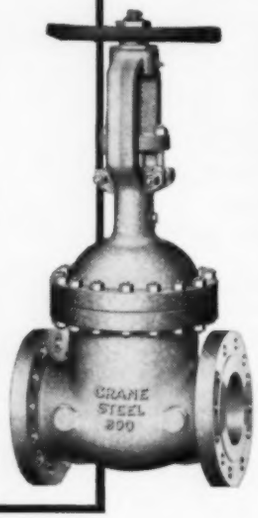
SERVICE LIFE:
38 yr.—still O. K.

OPERATING RESULTS:
Lowest cost steam control

AVAILABILITY:
Complete Crane line of modern patterns

The Valve

Like their 1916 counterpart designs, modern Crane Steel Valves give you performance that wins preference in every industry. They give you the values of steady leadership in steel casting . . . quality design . . . precise manufacturing. And the range of the Crane line in pressure classes, materials, and patterns, meets every need. See your No. 53 catalog, or your Crane Representative.



The Case History

Never, since installed in 1916, have these Crane valves been out of service for repairs. Only care given—and good care, obviously—is prompt repacking of the stuffing box and lubrication when needed. Such attention usually includes a general clean-up.

Neither infrequent operation nor the non-lubricating properties of steam have troubled these valves. They respond to the handwheel with smooth, positive action. High wear-resistance in seating materials keeps them tight as new, year after year.

Buying quality valves from the start assured this amazingly low-cost main line steam control. Today this buying policy is more justifiable than ever. And today as in 1916, better quality valves mean Crane valves.

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

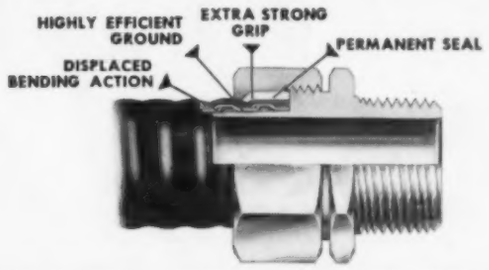
Superior BLAST FURNACE COPPER CASTINGS

Cooling Plates of all kinds including Heavy Nose Super Cooled Bosh Plates.
Hot Blast Valves and Valve Seats
Blast Furnace Tuyeres. Licensed Manufacturers of all Leading Designs

SMEETH-HARWOOD COMPANY
8524 Vincennes Ave., Chicago 20, Ill.
In Canada—The William Kennedy & Sons, Ltd., Owen Sound, Ontario

Blast Furnace Copper Castings—also Brass and Bronze Mill Castings

it's new— an improved connector for liquid-tight flexible conduit (Sealtite or equivalent products)



PYLE-NATIONAL

"CT" series Connectors offer all these advantages

EXTRA STRONG GRIP
- Compression force applied against body shank—not against the conduit alone, making a vise-like clamp.
- Plastic-to-plastic grip with the conduit sheath avoids cutting and abrasion

PERMANENT SEAL
- Plastic Sleeve and Conduit Sheath have equal physical characteristics. The seal will last the life of the conduit.

HIGHLY EFFICIENT GROUND
- Less than 10 millivolt drop.

DISPLACED BENDING ACTION
- Tapered body shank extends beyond gland nut, preventing short radius bends, lengthening life of conduit sheath and permanency of joint.

"CT" series connectors can be installed assembled. Available in Straight, 45° and 90° types for ⅜" to 2" conduit. Meet U/L and J.I.C. standards.

SINCE 1897

THE PYLE-NATIONAL COMPANY
1383 North Kostner Avenue Chicago 51, Illinois

your mill needs Gleason Reels

SM SERIES
Geared Reel • For Electric Cables • 125 Amps — 600 Volts • Continuous Contact • All Ball Bearings • Two-way Payout • Non-Revolving Springs • Fabricated Steel • Watertight • Replaceable Spring Motors • Adjustable Tension.

These reels were developed to meet the unusually severe operating conditions found throughout the steel industry and are of exceedingly rugged construction.

This type of reel can be furnished with 2, 3 and 4 conductor No. 4, 6 and 8 cable. Also, it can be easily adapted for use with larger size cable if necessary, with amperage rating up to 400 amps, 600 volts.

Gleason reels have been furnished to accommodate up to 28 conductor cable, and many other special features designed to meet individual applications.

Improved current collector and brush rigging, with extra wide spacing, minimizes the possibility of electrical troubles.

SEND FOR LITERATURE DESCRIBING THE COMPLETE GLEASON REEL LINE

Gleason Reel Corp.
Subsidiary of Maysteel Products, Inc.
Room 706
740 N. Plankinton Ave. • Milwaukee 3, Wisconsin

Easily-installed units for high-efficiency air movement in all duct systems. Direct-driven types for atmospheres within safe motor operating limits or belted models for hazardous fumes, vapors and excessive temperatures. Sizes 12" to 84" with 2, 4, 6, or 7 blades. Capacities to 120,000 C.F.M.

other models for every air-moving requirement

Certified Ratings

All Aerovent Fans are rated in accordance with the Standard Test Code and U.S.D.C. Comm. Std. CS178-51.

Ask for free folder D-50!

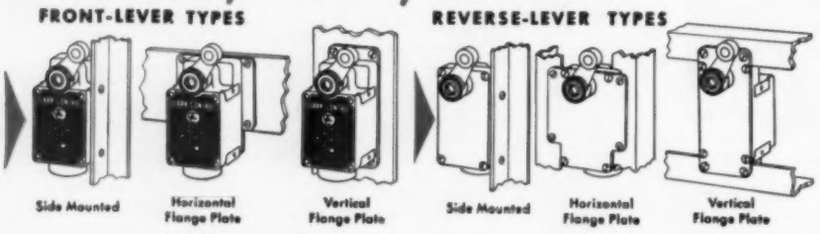
Aerovent Fan Company, Inc.
Ash and Brook Streets *Piqua, Ohio*

NEW!

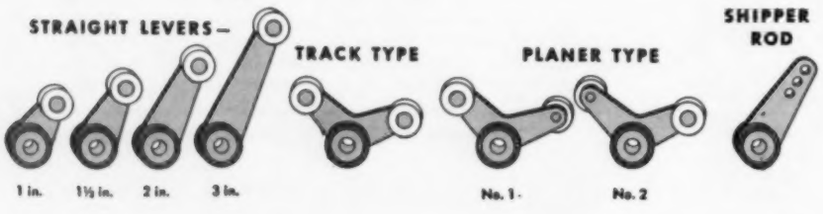
CLARK *Type DM* MACHINE LIMIT SWITCH

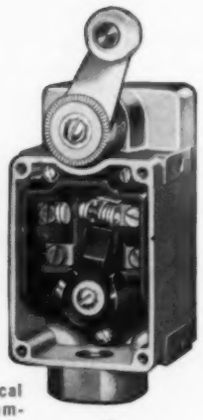
• This new heavy-duty limit switch is built with a minimum of moving parts, and with emphasis on simplicity of construction. The primary objective in its design is to provide dependable, accurate, trouble-free operation for a long life. All latch and trip-bearing surfaces are nylon to steel for minimum wear. All springs are in compression for greatest safety—they cannot be overloaded. This and other features make the switch as nearly fail-safe as possible.

Mounting Arrangements



Operating Levers





Nylon roller cushions impact, has low friction coefficient and long wearing qualities.

Reversible operating lever. Simple screw driver adjustment for reversing or positioning.

Heavy molded insulating chamber surrounds all live parts and provides ample wiring space for four No. 12 wires with Stakon connectors.

Areas subjected to arcing are protected by glass-melamine plates.

Electrical and mechanical sides of switch are completely isolated.

Nema Type 5 dust-tight, oil-tight enclosure of heavy die-cast construction.

Double-concentric overtravel springs in compression for fail-safe operation.

Return spring is in compression. Can be changed without tools to either side of arm, or removed for maintained contact.

Spring-loaded latches are nylon for low friction and long life.

Choice of ½" or ¾" conduit opening.

Write for Bulletin 102DM

The **CLARK CONTROLLER** *Company*

Engineered Electrical Control

1146 East 152nd Street ▪ ▪ Cleveland 10, Ohio

Personnel News...

Charles W. Cravens has been named second assistant district manager of Republic Steel Corp.'s Cleveland Plant. **Kurt G. Schultz** succeeds Mr. Cravens as superintendent of the open hearth department. **E. G. Kondas** replaces Mr. Schultz as assistant superintendent of the open hearth department. Mr. Cravens joined Republic in 1933. He was senior melter of Republic's electric furnaces in Chicago from 1942 to 1945 when he was named assistant superintendent of the open hearth department. In 1947 he was appointed assistant superintendent of the Chicago open hearths and electric furnaces and in 1953 became open hearth superintendent of Republic's Cleveland District. Mr. Schultz joined Corrigan-McKinney Steel Co., predecessor of Republic, in 1922. He has progressed through the various jobs of third, second, and first helper, melter, and general foreman in the open hearth to his immediate past and present positions.

Clarence R. Mitchell has been appointed hot strip superintendent of the Granite City Steel Co. Mr. Mitchell is in charge of the company's 90-in. hot strip mill. Before he came to Granite City, he was superintendent of the hot strip mill at the Birmingham, Ala. plant of the United States Steel Corp., Tennessee Coal and Iron Division. Prior to that, he was a roller in the cold reduction department of the Inland Steel Corp. plant in Indiana Harbor, Ind. Earlier, he was in the electrical department at the Steubenville, Ohio, plant of Wheeling Steel Co.

John P. Debri, general superintendent of the Joliet Works of American Steel & Wire Division of U. S. Steel Corp., has been promoted to a position in charge of special duties in the office of district manager of operations in Chicago. Succeeding Mr. Debri as general superintendent of the Joliet plant is **Joseph J. Just** who is being transferred from the post of assistant to the general superintendent at the Division's Donora, Pa. Steel & Wire plant. Mr. Debri joined American Steel & Wire in 1908. Since October, 1937, he has been employed in the operating department. In 1945, he was appointed division superintendent of the wire mill. He has been general superintendent of the Joliet Works since March, 1953. Mr. Just leaves Donora after 20 years' service in that plant. He joined U. S. Steel as a heater helper with the former Carnegie Steel Corp., in Clairton, Pa. In 1929, he joined the Canadian Steel Corp., Ltd. In March, 1934, Mr. Just returned to the Wire Division as a technical apprentice at Donora. He served successively as foreman of the cast billet department and the electric weld and fence department before being named superintendent of the wire and wire products division in April, 1943. He has been assistant to general superintendent since March of last year.

Jack Selway was appointed blast furnace superintendent of Chester Blast Furnace, Inc., a subsidiary of Barium Steel Corp. Mr. Selway comes to Chester with a record of 25 years in blast furnace operations. He started with Weirton Steel in 1929 and 12 years later went to the Provo, Utah plant of U. S. Steel Corp., where he remained for five years. Then, after two years with Republic Steel in Chicago, he left to become superintendent of the Ben Wood Works Furnace of Wheeling Steel.

A. A. Archibald has been named vice president of engineering and plant of Jones & Laughlin Steel Corp., and **F. T. Barton** has been named vice president of special products and services. The appointments were effective September 1. Mr. Archibald was formerly vice president of special products and services. Mr. Barton was general manager of J&L's container division.

W. L. Fabianic was elected as vice president in charge of research and quality control of Laclede-Christy Co. In addition, **P. K. Nichols** was elected as vice president in charge of operations.

Jacob W. Cox was named to the post of assistant to general superintendent of U. S. Steel Corp.'s Donora Steel and Wire Works. Mr. Cox succeeds **Joseph J. Just** who has been transferred to Joliet, Ill., as general superintendent of the Wire Division's plant there. Mr. Cox came to American Steel and Wire as an observer

CHARLES W. CRAVENS

KURT G. SCHULTZ

E. G. KONDAS

CLARENCE R. MITCHELL

in the physical laboratory in 1936. In 1948, he was named assistant to superintendent of the coke works. Since August, 1949, Mr. Cox has been division superintendent of blast furnaces in Donora.

Walter L. Brough, Jr. has been appointed chief engineer of Republic Steel Corp.'s Union Drawn Steel division. He succeeds **Alex Carnie,** who has been transferred to Republic's Truscon division in Youngstown. Mr. Carnie was associated with Truscon for 18 years

WALTER L. BROUGH, JR.

before joining Union Drawn in 1945. In his new position Mr. Brough will supervise engineering activity at Union Drawn plants in Massillon, Beaver Falls, Pa., East Hartford, Conn., Gary, Ind., Los Angeles, Calif. and at a Republic subsidiary in Hamilton, Ontario — Union Drawn Steel Co., Ltd.

Arthur T. Davis has retired as vice president and director of sales of the Morgan Engineering Co. He will continue his association with the company in an advisory capacity.

Walter F. Larson was appointed chief engineer and **Donald E. Russell** was named sales manager of the new Hydraulic Equipment Department of Sutton Engineering Co.

Dieter Hancke, application engineer of the well-known German firm of Maschinenfabrik Meer, manufacturer of high-speed tube mill equipment, is visiting the U. S. to assist the company's American affiliate, Mannesmann-Meer, in a study of local needs in the field, and to make himself acquainted with the best operating practices in this country.

J. Robert Pauline has been appointed vice president of the Kellogg Division of American Brake Shoe Co. Previously division works manager, Mr. Pauline started with the company as an engineer in 1943.

Frank W. Zurn was appointed manager of engineering sales of J. A. Zurn Manufacturing Co.

Michael D. Barnett has joined Carboloy department of General Electric Co. as a sales representative for the midwestern district. He will reside in the Chicago area.

William A. Coolidge was elected a director of Crucible Steel Co. of America. He succeeds W. W. Anderson, who resigned.

Edward C. Vorlander was appointed managing director of Honeywell-Brown, Ltd., British subsidiary of Minneapolis-Honeywell Regulator Co.

C. J. Chapman was appointed general sales manager of industrial products for National Carbon Co. Mr. Chapman, who will be located in the company's general

C. J. CHAPMAN

offices in New York, will direct sales activities on the company's carbon and graphite electrodes, protector carbons, carbon brushes, signal cells, and chemical and metallurgical carbon products.

Robert J. Ely has been appointed assistant chief metallurgist for the American Brake Shoe Co. Formerly process metallurgist, Mr. Ely joined the company in 1945. He is located at the company's research center in Mahwah, N. J.

John Lawrence was elected executive vice president of Joy Manufacturing Co.

L. Jack Clarke was appointed general sales manager, Leschen Wire Rope Division, H. K. Porter Co. Mr. Clarke has served Leschen as field representative in the New Orleans area and as manager of the New York sales district. He will make his headquarters at the division's main offices in St. Louis.

George W. Brown, executive engineer of Wagner Electric Corp., was elected a vice president. In his new capacity Mr. Brown will have complete charge of Wagner's engineering and research divisions, both automotive and electrical, and will also serve as a member of the company's executive committee.

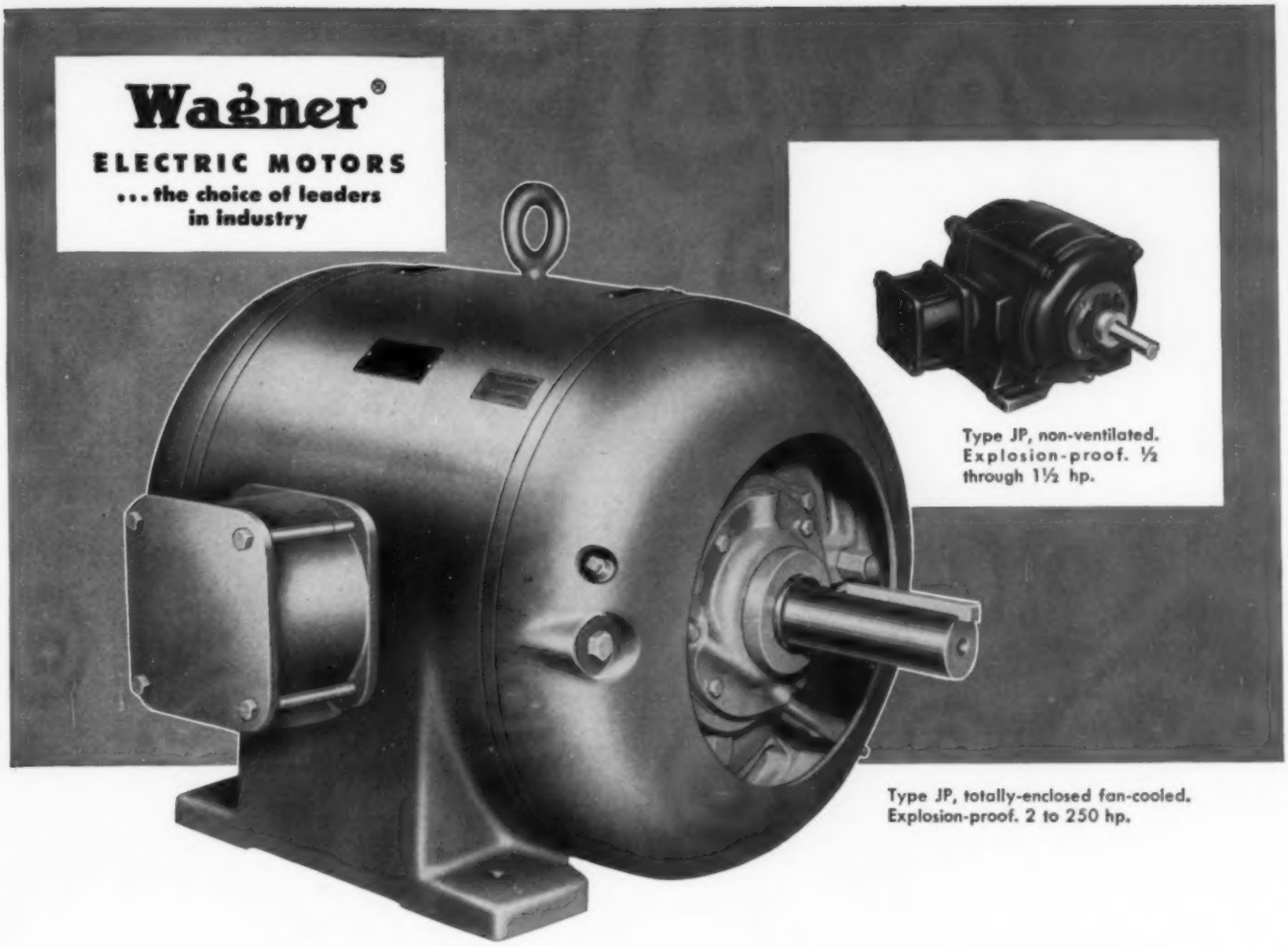
Robert H. Aborn, assistant director of U. S. Steel Corp.'s Kearny, N. J. research laboratory since 1947,

Wagner®

ELECTRIC MOTORS

... the choice of leaders in industry

Type JP, non-ventilated. Explosion-proof. ½ through 1½ hp.



Type JP, totally-enclosed fan-cooled. Explosion-proof. 2 to 250 hp.

for extra protection against corrosion

SPECIFY **Wagner** *CAST IRON FRAME MOTORS*

Here are stock motors specifically designed for use in chemical plants, oil fields, refineries, steel mills—for rugged industrial applications where dust, dirt, moisture, or corrosive vapors are present.

These motors are totally-enclosed in corrosion-resistant cast iron and all parts exposed to the atmosphere are of corrosion-resistant material—including the nameplate. They feature completely protected laminations . . . special varnish treated windings . . . and a running shaft seal.

Wagner Cast Iron Frame Motors are available in fan-cooled standard and explosion-proof types in ratings from 2 to 250 hp, and in non-ventilated standard and explosion-proof types in ratings from ½ through 1½ hp. Wagner Bulletin MU-132 gives complete information.

A skilled Wagner engineer can help you select a Wagner Motor to meet your most exacting specifications. Call the nearest of our 32 branch offices, or write us.

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AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

MH-4

LINTERN ANNOUNCES

NEW MODEL

AIRE-RECTIFIER

ON DISPLAY AT THE IRON & STEEL SHOW

New cab unit. Parts are even more accessible than in previous models.

Reflecting the experience gained in more than 1000 crane cab installations throughout the past 14 years, these new models offer many advantages.

Horsepower is increased, with a 50% reduction in the number of motors used in the condenser unit, yet there are no multiple belt drives to complicate maintenance.

All three models include many features available only in Lintern machines, such as the all-copper integral fin coils for long life and high efficiency, oil separator to protect the compressor, pressure gauges for quick checking of machine operation, dehydrator, blade type condenser fan, oversize drip pan and generous sized drip pan drain, activated carbon and mechanical filter purifying both make-up and re-circulated air, high pressure protective device, vibration eliminators both in the condenser unit and in the connecting lines between the condenser and cab units.

Yet — with all these features we have been able to maintain minimum dimensions for easy, inexpensive installation with unexcelled service and efficiency. Most of the component parts are interchangeable with older models enabling users to keep spare parts inventory at a minimum.

May we send you complete information? Ask for Bulletin 549.

THE LINTERN CORPORATION

ROUTE 20, EAST • PAINESVILLE, OHIO

has been named director. Dr. Aborn has been associated with U. S. Steel for the last twenty-four years. **Lawrence S. Darken, Bernard M. Larsen, Donald S. Miller** and **Reginald L. Rickett,** members of the Kearny staff for many years, have been named assistant directors, respectively, of physical chemistry, metallurgical processes, physics and physical metallurgy.

L. A. Vaughn, president of Vaughn Machinery Co. since 1929, has become chairman of the board. In other changes, **James A. Vaughn,** formerly vice president,

L. A. VAUGHN

was named president and general manager, and **Gordon C. Vaughn** was elected vice president of manufacturing. **Allan Vaughn** continues as secretary of the company. **E. J. McIlvried** is now senior vice president and director of engineering. He has been vice president and director since 1935.

JAMES A. VAUGHN

W. T. Bosworth has been appointed manager of sales of rotary hearth furnace and heat treating equipment for Salem-Brosius, Inc. Mr. Bosworth has been affiliated with the George J. Hagan Division of Salem-Brosius for 25 years as director of sales activities in the Chicago district.

Edwin T. Lorig, chief development engineer of the U. S. Steel Corp., will be the recipient of a John Price

Why it pays to specify
TORRINGTON Spherical Roller Bearings

Uniform, close control of precision-ground contact surfaces—for even load distribution, maximum bearing life.

Accurate geometrical conformity between races and rollers—for ultimate capacity and performance.

Races and rollers heat treated according to the most advanced metallurgical procedures.

Machined, cast-bronze cages—one for each path of rollers—assure freedom of operation.

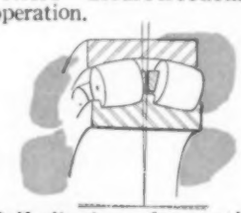
Integral center flange on inner race—to give positive radial and thrust stability—both essential to satisfactory performance.

Available from stock with either straight or tapered bore—for shaft or adapter mounting.

These are advantages that give you long, efficient, low-maintenance service in the toughest heavy-duty applications... **maximum value for your bearing dollar.** ***That's why it pays to specify TORRINGTON Spherical Roller Bearings.***

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

TORRINGTON SPHERICAL ROLLER **BEARINGS**



Self-aligning—for continuous, free-rolling service under shock loads and at sustained speeds.

Unit assembly—for easy, low cost handling.

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

Argon gas being used as a backing agent replacing backing rings . . . Welding operations are fast and simple.

ELIMINATE Backing Rings

in Stainless Steel Piping with HELIARC Welding

Trade-Mark

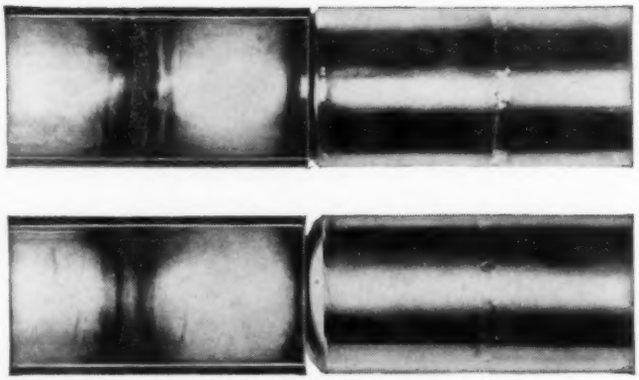
The combination of stainless steel pipe and HELIARC welding with argon gas backing produces a corrosion-resistant piping system—ideal for handling foods, fluid metals, corrosive liquids, high-pressure and high-temperature steam, and pharmaceutical products.

No backing rings—argon replaces the atmosphere in the section of pipe to be welded, and protects the weld bead from the underside as it is formed. This eliminates the need for metal backing rings.

New torch techniques allow the operator to control the size and shape of the penetration bead inside the pipe, while he is making the weld.

Smooth, sound joints—every time. HELIARC welding produces joints free from obstructions, notches, and crevices which hinder or trap flowing materials within the piping system. The penetration bead in the pipe is held within 1/32-in. of the pipe's normal inside diameter.

For the full story on argon-backed, stainless steel pipe fabrication, ask your local LINDE representative for the booklet, "Inert-Tungsten Arc Welding of Stainless Steel Piping," F-8463. In addition, he will be glad to give you complete information on how HELIARC welding cuts time and cost in many other applications. Start saving now—call him today.



Top—interior and exterior of completed welds without argon backing. Bottom—with argon backing, note the smooth, porosity-free, high quality welds.

Linde Air Products Company

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY

Division of Union Carbide Canada Limited, Toronto

Linde Trade-Mark

"Heliarc" and "Linde" are registered trade-marks of Union Carbide and Carbon Corporation.

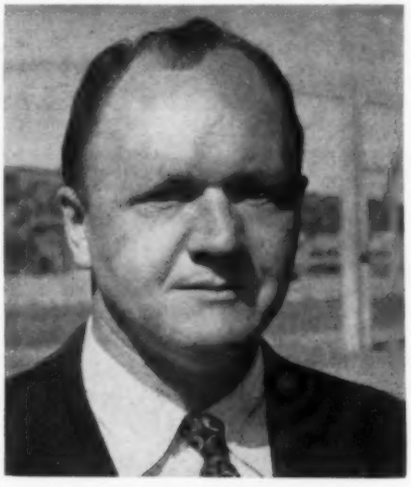
Wetherill Medal of the Franklin Institute of the State of Pa., October 20 at the Institute's annual Medal Day ceremonies. The award is being made in consideration

EDWIN T. LORIG

of his invention of the Lorig-Aligner self-centering roll, which was first publicized at the AISE convention in 1950.

Dr. Wayne E. Kuhn has been named general manager of the newly-created research and technical department of the Texas Co.

Edwin H. Engel has joined Follansbee Steel Corp. as chief of quality control. He is making headquarters at the mill in Follansbee, W. Va. For the past five years Mr. Engel has been chief metallurgical engineer and



EDWIN H. ENGEL

assistant to the general superintendent of Compania de Acero del Pacifico, Huachipato, Chile. Before leaving for South America, Mr. Engel spent a year in New York City in the planning phase of metallurgical engineering for this plant.

Howard B. Huntress was appointed director of research of the newly-organized Sintermet division of American Brake Shoe Co. As a metallurgist in the company's research center, Mr. Huntress has been engaged in research in powder metallurgy on sintered metal friction materials since joining the company in 1944.

R. W. Crawford was promoted to manager of machinery sales and sales promotion of the Lombard Corp.

Maurice A. Nye has been named chief engineer of the Vaughn Machinery Co. He has been assistant chief engineer since 1950 and has been associated with the engineering department since 1927.

C. C. Blandy has been appointed new Philadelphia district sales engineer for J. H. France Refractories Co. In his new capacity, Mr. Blandy will work with the Van Brunt Co., Philadelphia distributors of the company's firebrick, castables, mortars, combustion chambers, plastic firebrick and specialty refractory products.

Donald A. Comes was elected vice president of Farrel-Birmingham Co. He will also continue to hold his present position as general sales manager.

DONALD A. COMES

Robert M. Breckenridge will head the new St. Louis sales zone of the Selas Corp.

Julius E. Graf, chief engineer of Jones & Laughlin Steel Corp., will retire October 1. Mr. Graf joined J&L in 1940 as assistant chief engineer. Prior to that time, he had served with the American Sheet and Tin Plate Co. from 1911 to 1936, being chief engineer from 1930 up to the consolidation of that company with Carnegie-Illinois Steel. He was assistant chief engineer of the Carnegie-Illinois Steel Corp. from 1936 to 1939 and was vice president of Treadwell Engineering Co., 1939-1940. Mr. Graf still is a member of the board of directors of Treadwell. He became chief engineer at J&L on January 1, 1947.

Clinton H. Johnson was appointed sales engineer for electrostatic precipitators at the Chicago district office of the metal products division of Koppers Co., Inc. Mr. Johnson's responsibilities will include field sales and service to customers for Koppers electrostatic precipitators in the Chicago area.

William A. Hughes has been named vice president of sales for Standard Boiler & Plate Iron Co. Mr. Hughes was formerly sales manager of the company.

WILLIAM A. HUGHES

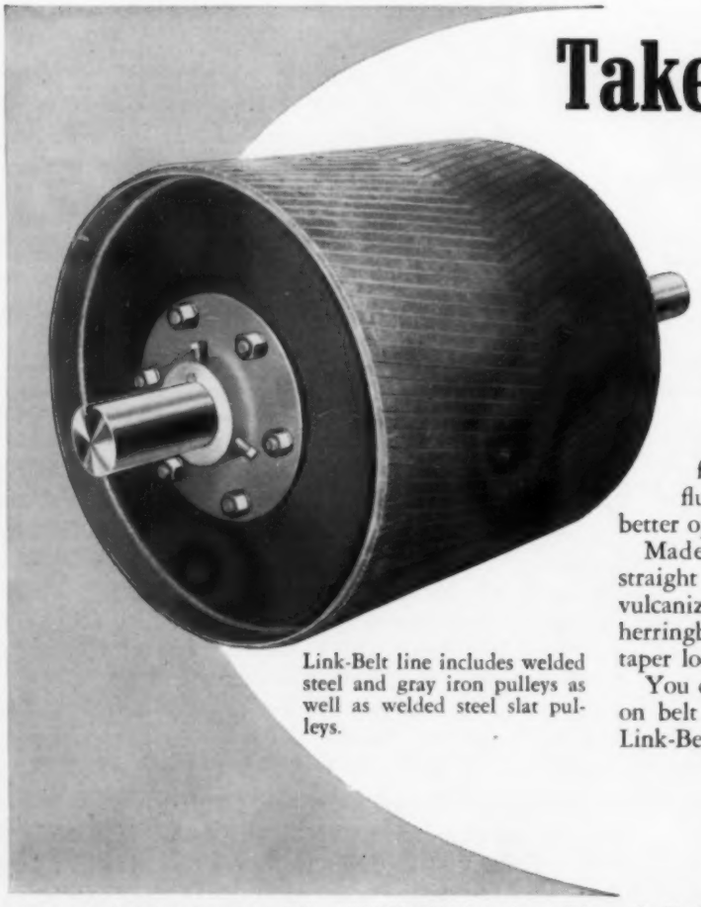
I. Wendell Hamm has been appointed director of manufacturing for the Carborundum Co.

Edward H. D. Gibbs has been appointed sales manager of Heyl & Patterson, Inc. Mr. Gibbs joined Heyl & Patterson in 1948 as a contracting engineer and has served in that capacity until his recent appointment. Prior to joining the company, he had worked in various engineering capacities for United States Steel Corp. since 1937.

EDWARD H. D. GIBBS

Joseph H. Myers has been appointed assistant general superintendent of the company's plant in Riverdale, Ill. **Herman H. Lentfer** succeeds Mr. Myers as superintendent of the manufacturing and processing division of the Riverdale plant.

Dale R. Knouse, for over twenty years in the engineering department of Aluminum Co. of America, has



Takes the work out of field mounting

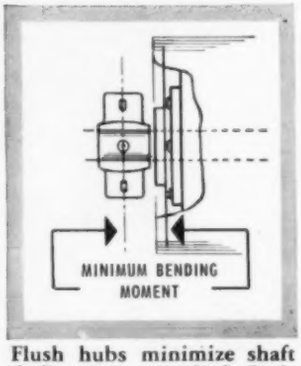
LINK-BELT assembles pulley on shaft—insures correct keyseat alignment

Link-Belt line includes welded steel and gray iron pulleys as well as welded steel slat pulleys.

YES, you get a two-way dividend because Link-Belt mounts belt conveyor pulleys on their shafts at the factory. What's more, the flush-hub construction means better operation.

Made with either crowned or straight face, they are available with vulcanized lagging, either plain or herringbone. Your choice of bolted or taper lock hubs.

You can get complete information on belt conveyor pulleys from your Link-Belt salesman. Call him today.



Flush hubs minimize shaft deflection, cut hub bolt stress and disc deflection.

LINK-BELT

WELDED STEEL CONVEYOR PULLEYS

12,424-A

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

NEW AIR-BREAK STARTER for 2,200 to 5,000 Volt Motors features 50,000 KVA Capacity

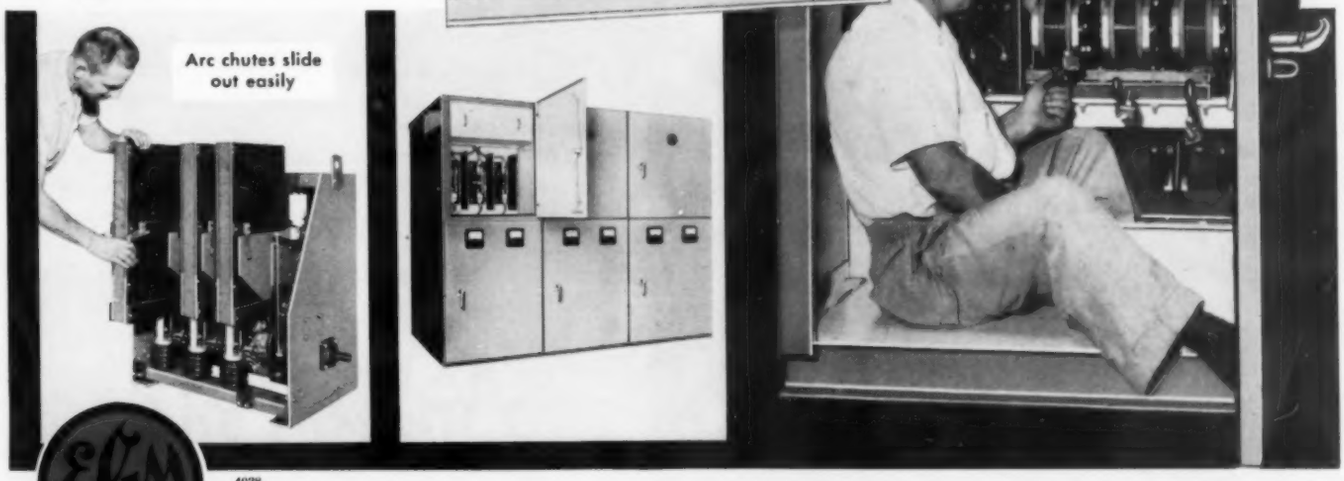
CERTIFIED

FOR FANS, PUMPS, COMPRESSORS, CONVEYORS, CRUSHERS, AIR CONDITIONING UNITS, MILL MACHINERY

Designed for a wide range of applications, this new EC&M type ZHA Air-Break Motor Starter utilizes magnetic contactors having(certified)50,000 kva interrupting capacity. For circuits of higher fault capabilities, Volt-Ampere-Limitor (VALIMITOR) Starters, with air-core reactors, limit infinite available kva to a low finite value for interruption by the ZHA Contactor.

These new 50,000 kva and Volt-Ampere-Limitor (VALIMITOR) Starters are available in a wide range of sizes for squirrel-cage and synchronous motors as well as for wound-rotor motors. Starters can be furnished in standard, gasketed and weather-resistant enclosures.

Write today for Catalog No. 1060



4028

THE ELECTRIC CONTROLLER & MANUFACTURING COMPANY

2698 EAST 79th STREET • CLEVELAND 4, OHIO

joined the sales engineering staff of the Vaughn Machinery Co.

Robert A. Embree has been appointed process and plant engineer of the motor-generator division of Chandeysson Electric Co.

ROBERT A. EMBREE

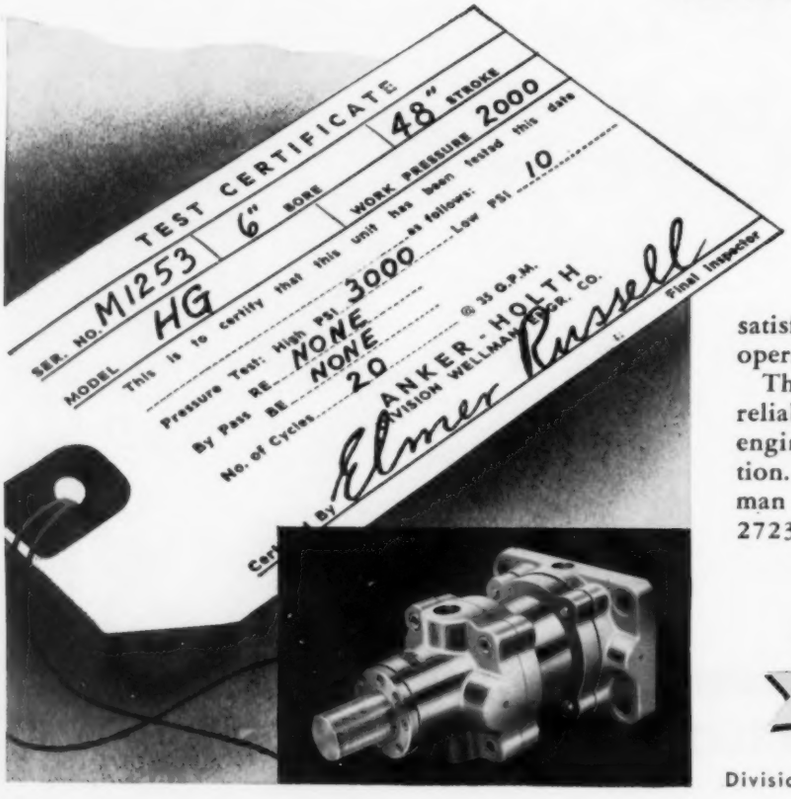
Alfred Sonntag, manager of the Sonntag Scientific Corp., a division of Baldwin-Lima Hamilton Corp., resigned this position to devote his time more exclusively to the Alpha Corp., Greenwich, Conn., of which he is president. He will continue in an engineering consultant capacity for Baldwin-Lima-Hamilton. Mr. Sonntag came to this country in 1930 from Germany where he had been chief engineer for Lowenhousenwerk, Dusseldorf, a testing machine manufacturer. He joined Riehle Brothers Testing Machine Co. in Philadelphia as a development engineer. Later he became chief engineer and sales manager. In 1942 he organized Sonntag Scientific Corp. for the development of fatigue and simulated service testing machines. Later, he sold the company to Baldwin-Lima-Hamilton, remaining with the firm as general manager.

Obituaries

George March, works superintendent at the Cleveland plant of American Steel & Wire Co., died August 23. He was 37. Mr. March joined the company in 1940. He was named works superintendent at Central Furnaces and Docks in 1950.

Alfred J. Porter, a vice president and director of Heppenstall Co., and manager of the company's plant at Bridgeport, Conn., died August 11. He was 58 years old. Mr. Porter served as president and director of Heppenstall Co., Bridgeport, a subsidiary, since 1942. He was elected a vice president of the parent company in February, 1954.

Every Anker-Holth Cylinder is certified at 1½ times working pressure


TEST CERTIFICATE
SER. NO. M1253
6" BORE
48" STROKE
MODEL HG
WORK PRESSURE 2000
This is to certify that this unit has been tested this date as follows:
Pressure Test: High PSI 3000 Low PSI 10
By Pass RE NONE
BE NONE
No. of Cycles 20 @ 35 G.P.M.
ANKER-HOLTH DIVISION WELLMAN ENGR. CO.
By Elmer Russell
Final Inspector

This safeguard of dependable performance is yours when you SPECIFY ANKER-HOLTH CYLINDERS

● Each Anker-Holth Cylinder is tested at 150% of working pressure with the latest completely-filtered testing equipment. A tag such as shown at left certifies to its satisfactory performance under these above-normal operating conditions.

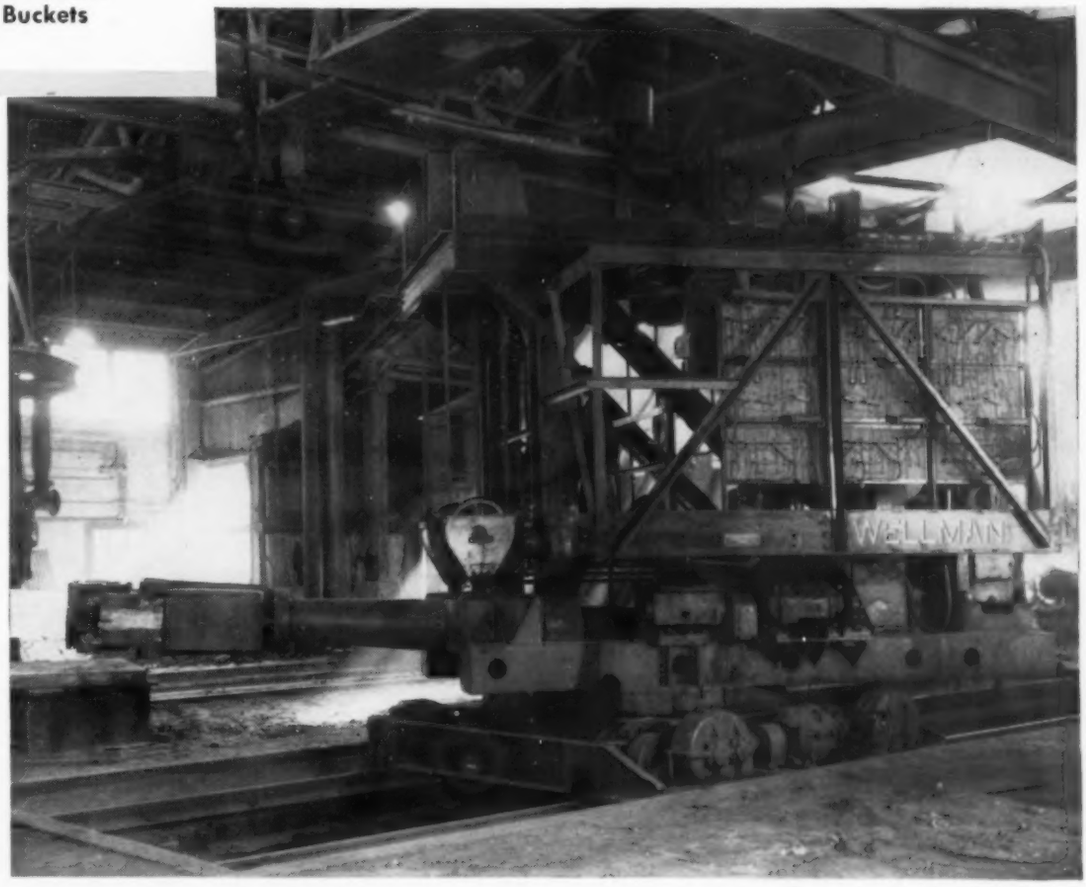
This is another reason why it pays to specify reliable Anker-Holth Cylinders. Call or write for engineering help on your problems in power motion. ANKER-HOLTH DIVISION of The Wellman Engineering Company, Department E-11, 2723 Conner Street, Port Huron, Michigan.

Anker-Holth
ENGINEERED CYLINDER POWER
WELLMAN
Division of THE WELLMAN ENGINEERING COMPANY

Wellman will build it

Special Cranes
Forging Manipulators
Charging Machines
Ore Unloaders
Car Dumpers
Gas Flue Systems
Gas Reversing Valves
Coke Pushers
Mine Hoists
Skip Hoists
Ore and Coal Bridges
Clamshell Buckets

→ **Wellman forging manipulators** handle big ingots speedily, efficiently



Wellman Forging Manipulator with white-hot ingot ready for forging.

● Wellman Forging Manipulators hold hot steel ingots on anvil dies, turn them and keep them level for efficient forging . . . despite hammering shocks. You can count on *all* Wellman equipment for speedy, economical service. It is backed by more than a half century of leadership in designing manufacturing and construction of heavy materials handling facilities.

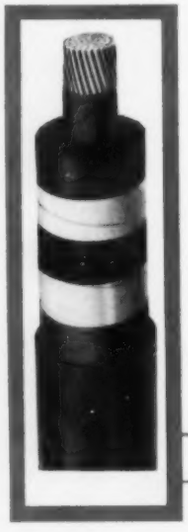
THE WELLMAN ENGINEERING COMPANY

7010 CENTRAL AVENUE • CLEVELAND 4, OHIO

there's an OKONITE cable

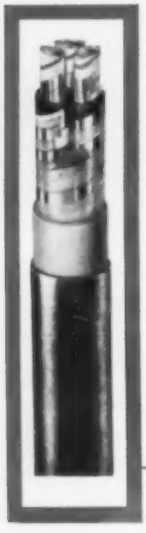
1 **Okolite-Okoprene Rubber Insulated Control Cable** provides double sheath protection with a color-coded Okoprene sheath over each conductor and a heavy Okoprene sheath over the cable assembly. Resistant to moisture, heat, oil and vibration, they operate at 75C.

(Bulletin IS-1056A)



2 **Okolite-Okoprene Rubber Insulated Shielded High Voltage Power Cables** are flexible, light weight and easy to splice and terminate. Resistant to ozone, heat and moisture, they are available for operation at 75C up to 35kv.

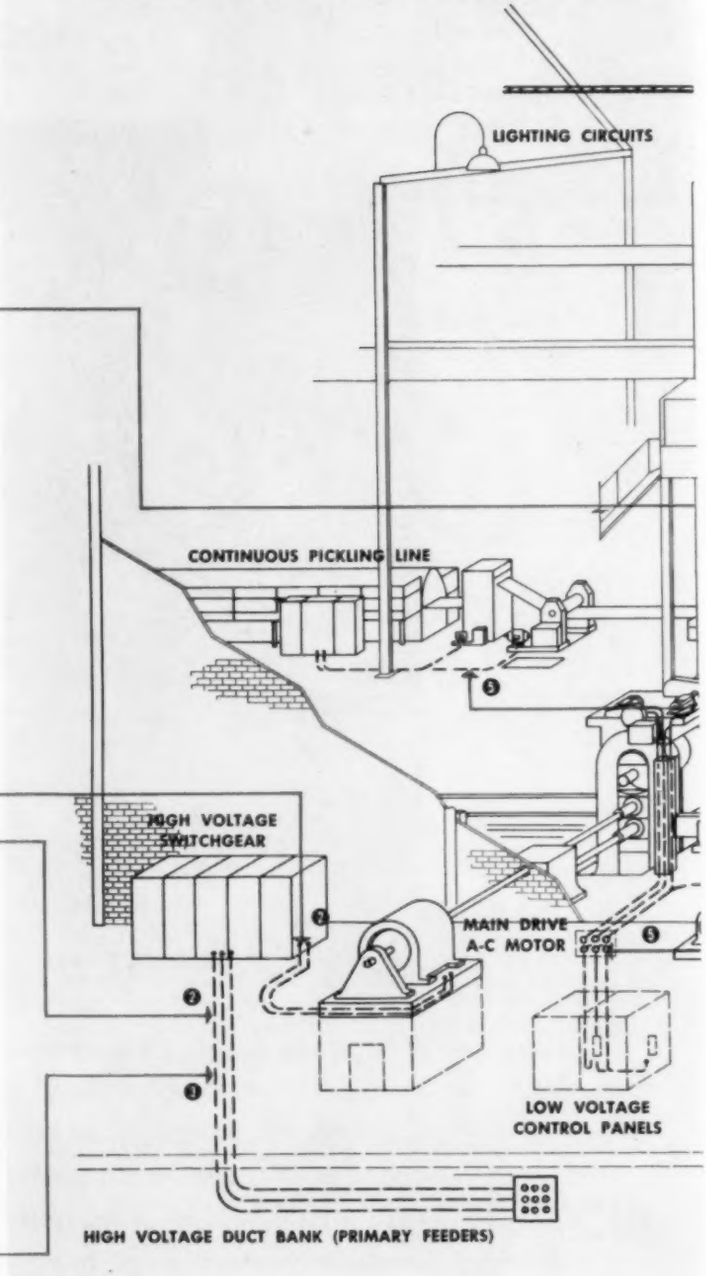
(Bulletin IS-1075)



3 **Okocal Paper Insulated Power Cables** are made in accordance with AEIC Specifications for operation up to 75kv. Life extending metallized paper tape construction and reduced lead sheath thickness with corrosion proof coverings provide an economical, durable installation.

(Bulletin IS-1047)

SCHEMATIC DIAGRAM



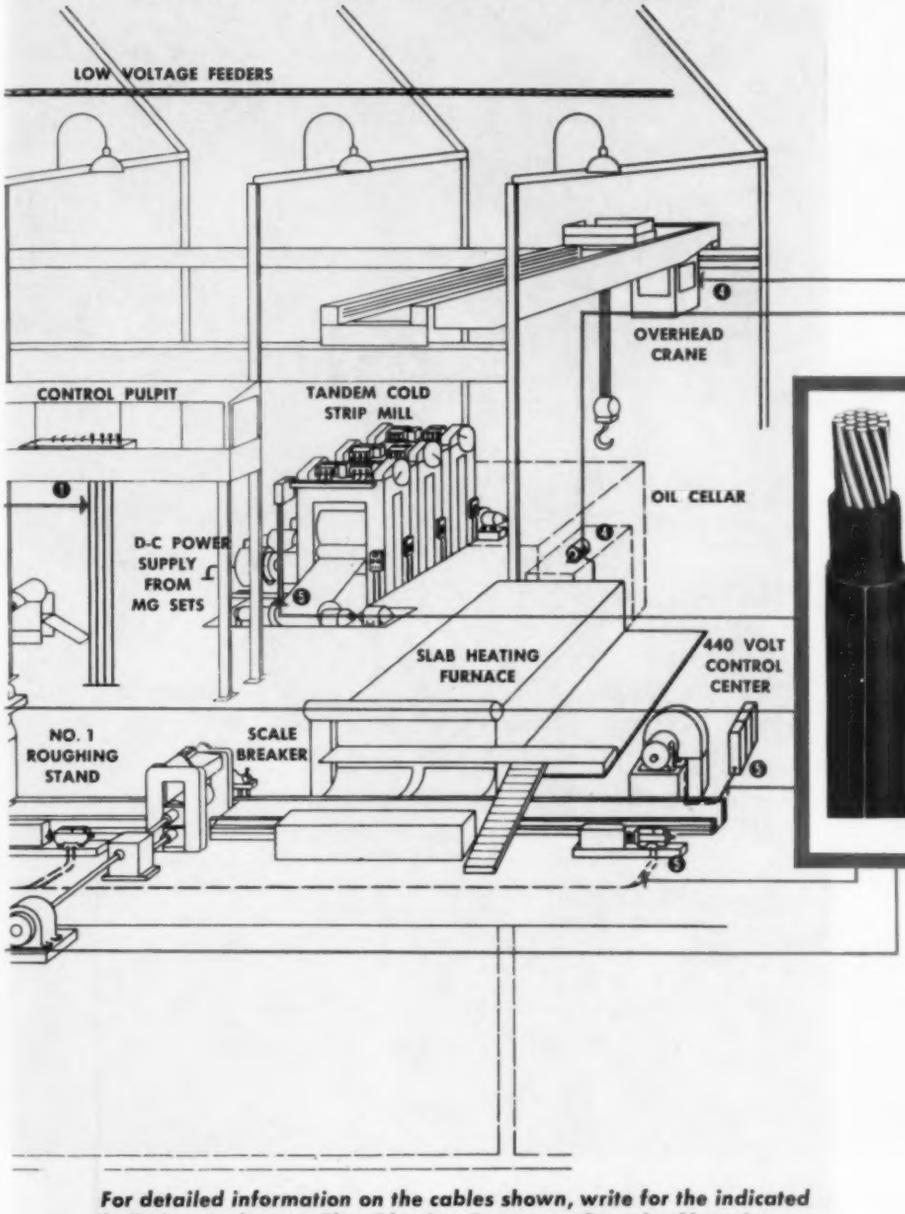
OKONITE

OKONITE SINCE 1878

2722

for every steel plant use

OF A TYPICAL STRIP MILL



4 **Okotherm Silicone Insulated Power and Control Cable** for continuous high temperature use at 150C and for special applications up to 200C. Glass braids are applied over the individual conductors and overall. Conduit can be eliminated by having a seamless aluminum sheath in place of the braid.

(Bulletin IS-1088)

5 **Okolite-Okoprene Rubber Insulated Power Cables** are recommended without shielding for operation at 75C up to 5000 volts. Resistant to ozone, heat, moisture, oil and vibration, these non-metallic sheathed cables are easy to splice and terminate. Thirty years service experience with Okolite rubber insulation has proved its high dielectric strength and reliability.

(Bulletin IS-1085)

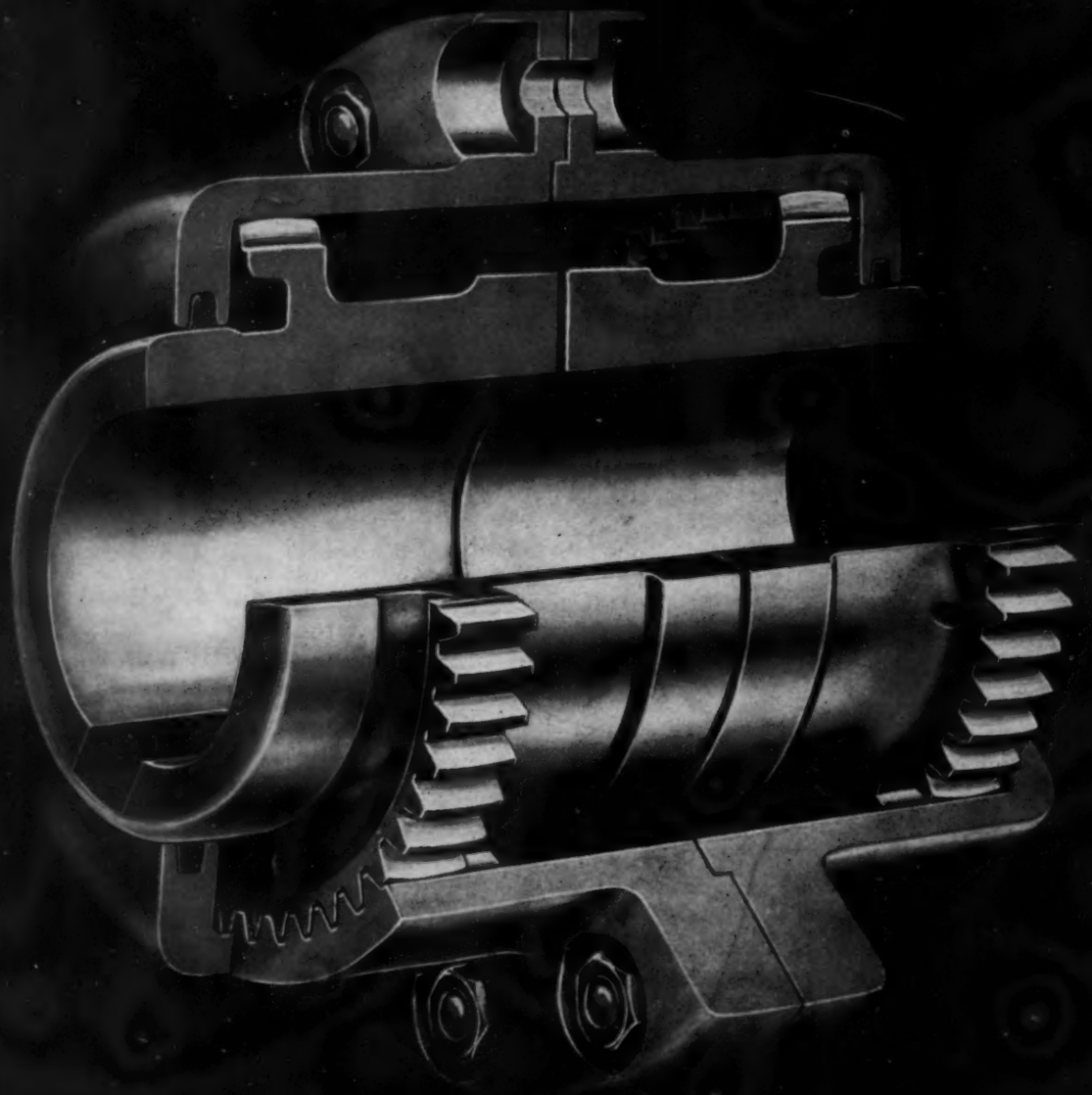
6 **Hazacord Rubber Insulated Flexible Cords and Portable Cables** are always cured in a metal mold to provide the toughest, most durable construction. Resistant to mechanical abuse, heat, moisture and oil, these extremely flexible cables are available in all common sizes and voltage ranges.

(Bulletin IS-H-451)

For detailed information on the cables shown, write for the indicated bulletin number to The Okonite Company, Passaic, New Jersey.

insulated cables

POOLE



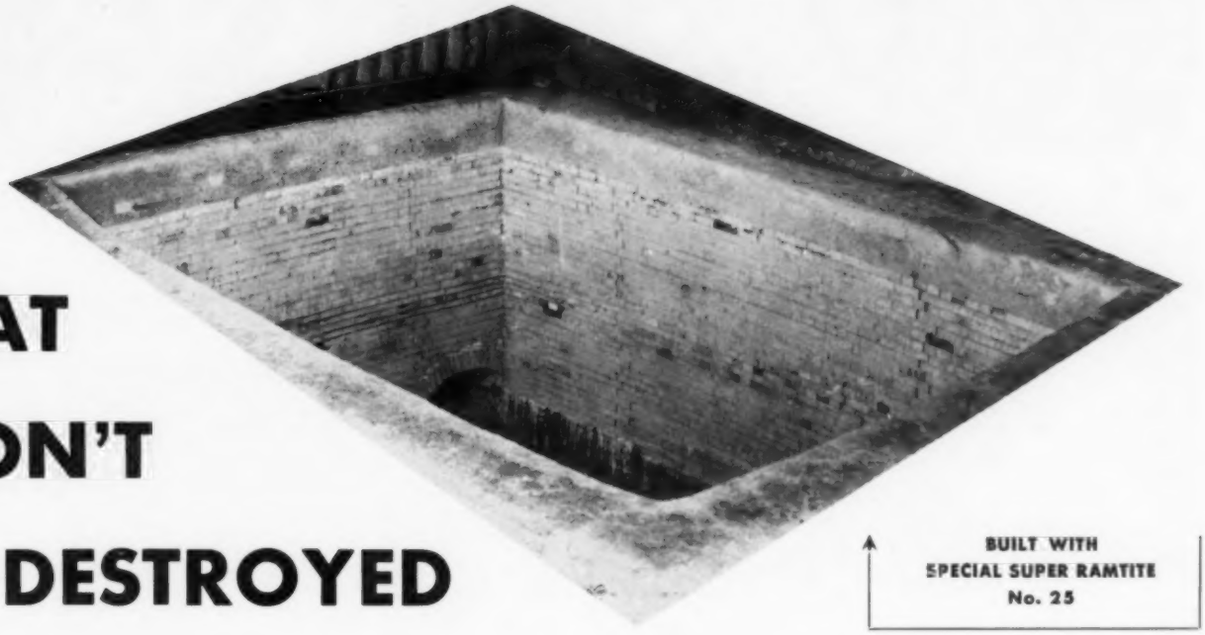
A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

HERE'S A SOAKING PIT COPING THAT WON'T BE DESTROYED BY AN INGOT FIN!



BUILT WITH
SPECIAL SUPER RAMTITE
No. 25

There are no joints for a fin to hook into, therefore no solid grip with which a fin can pull the coping out. This RAMTITE coping may be scratched and gouged, but it won't be torn out. The company for which this coping was installed is satisfied. They've got 24 more like it, all giving good service.

In this particular case the cost of the Special Super Ramtite No. 25 was 35% lower than the high alumina tile used previously, a substantial saving. The long run savings effected with Ramtite Plastic Refractories is also substantial, meaning a lower inventory, easier installation, longer life, and more dependable service.

Ramtite Plastic Refractories have proven themselves outstanding for rough duty applications. And in the Steel Industry as anywhere else, it's performance that counts. We feel it is the reason for the ever increasing use of Ramtite Refractory Products.

RAMTITE IS OUR BUSINESS, NOT OUR SIDELINE. Our experience in the field — over 30 years — qualifies us to help you with your specific refractory problem. Contact your local Ramtite Representative, or send us the attached coupon.

VISIT US AT OUR BOOTH Nos. 328-329 IRON AND STEEL EXPOSITION

THE Ramtite CO.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of the S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send the items checked:

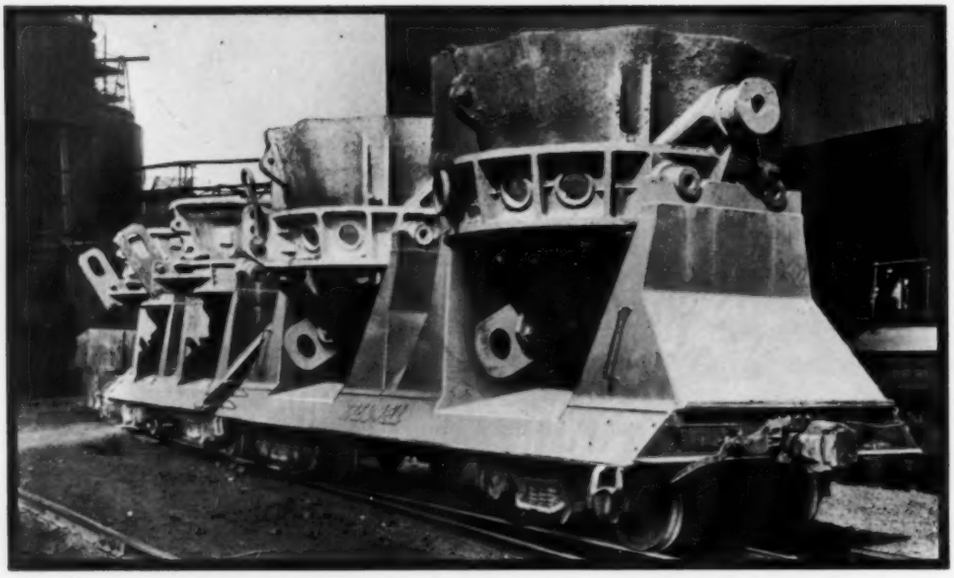
- ☐ Bulletin on Castable and Gunning Refractories
- ☐ Steel Plant Bulletin

Company Name.....
Attn. Mr.....Title.....
Address.....
City.....Zone.....State.....

This is another in a series of advertisements depicting ways Ramtite Refractories serve the Steel Industry.

TREADWELL

CINDER CARS



400 CUBIC FOOT TWIN POT CRANE DUMP CINDER CAR
FOR OPEN HEARTH SERVICE

FOR

BLAST FURNACE

OPEN HEARTH and

ELECTRIC FURNACE SERVICE

Single, Twin and Multiple Pot Cars

OPERATED BY

AIR - STEAM - ELECTRIC MOTOR or CRANE

M. H. TREADWELL CO., INC.

208 S. LA SALLE ST.
CHICAGO 4, ILL.
CEntral 6-6784

140 CEDAR STREET
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WOrth 4-2244

1015 FARMERS BANK BLDG.
PITTSBURGH 22, PA.
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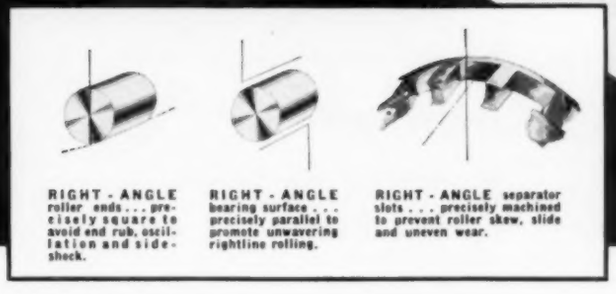
HEAD, WRIGHTSON, LTD., Thornaby on Tees, England

UNWAVERING ORBITAL ROTATION

Because every surface is precisely square . . . precisely parallel. No skew . . . No skid . . . No oscillation



RIGHT - ANGLE roller ends . . . precisely square to avoid end rub, oscillation and side-shock.

RIGHT - ANGLE bearing surface . . . precisely parallel to promote unwavering rightline rolling.

RIGHT - ANGLE separator slots . . . precisely machined to prevent roller skew, slide and uneven wear.

ROLLWAY right-angle solid cylindrical roller bearings

Loaded at right angles, with no diagonal components to impose skew forces. Precisely square and parallel from every surface aspect. The solid cylindrical rollers of Rollway Right-Angle Roller Bearings follow the right-line motion of Newton's first law, providing *unwavering orbital rotation around the shaft.* Internal friction and heat are held to a minimum. Maintenance attention and replacement costs are low . . . life and load-performance qualities surprisingly high.

Our engineers will gladly assist you in selecting the best bearing for your particular needs. Complete engineering and metallurgical services are always at your command. No cost. No obligation. Just write or wire. Rollway Bearing Co., Inc., Syracuse, N. Y.

ROLLWAY BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

See the Rollway Display at the Iron & Steel Exhibition
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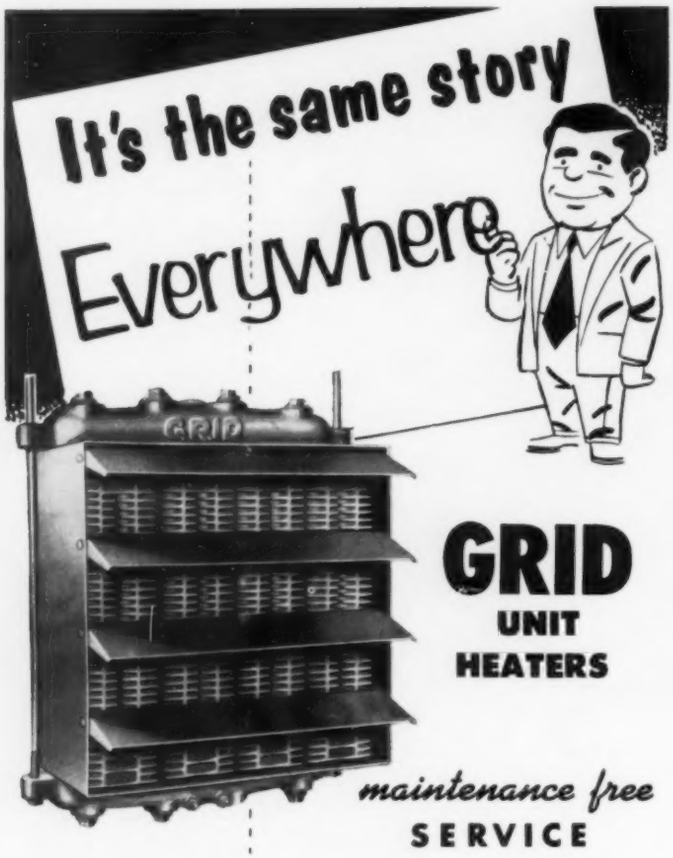
SALES OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • Philadelphia • San Francisco • Boston • Detroit • Pittsburgh • Milwaukee • Houston • Los Angeles



GRID
UNIT HEATERS

maintenance free
SERVICE
since 1929!

"We have in service GRID Unit Heaters type No. 2500. A number of them have been in use for approximately 10 years, and some of the units are on very severe service where the steam is turned on and off several times each day, the valves being turned on and off rapidly. Even under this severe service we have found them to be maintenance free."*

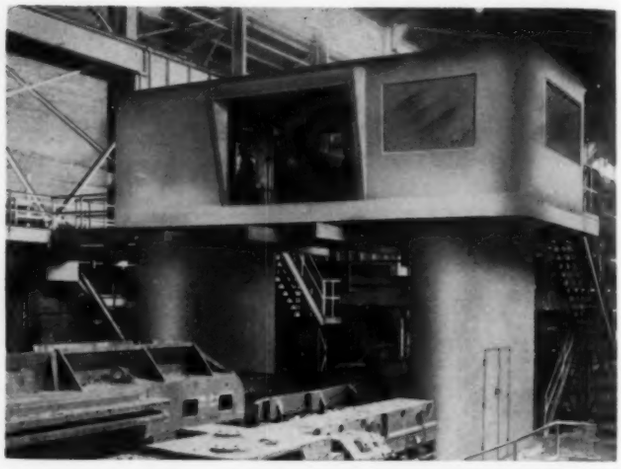
*Copy of a letter from a Midwest Steel Mill, name upon request.

Maintenance cost concious management men turn to GRID for relief from the continous expense of heating failures experienced with ordinary unit heaters. GRID UNIT HEATERS installed in 1929 are still operating today and here is why: GRID's All-Cast construction having similar metals in contact with steam prevents electrolytic corrosion. GRID's ability to withstand steam pressures up to 250# P.S.I. GRID's low outlet temperatures, proper fan sizes and motor speeds assure delivery of warm comfortable air in ample volume, directly to the spot where it is needed.

Write today for complete information. Ask for booklet, CORROSION IN UNIT HEATERS it's yours upon request.

D. J. MURRAY MANUFACTURING CO.
Manufacturers Since 1883 • Wausau, Wisconsin

MODERN
MILL PULPITS



IMPROVE EFFICIENCY

1 — Individually Designed.

2 — Shipped Completely Assembled.

3 — Extra Heavy Construction.

4 — 100% Insulated.

5 — Streamlined.

6 — Safety Window Glass.

7 — Concealed Wiring and Piping.

8 — Control Desks and Conduits Installed before Shipment.

9 — Operators Work in Silence.

10 — Indirect Non-Glare Lighting.

11 — Accessories: Air Conditioning, Rest Room, Lockers, Chairs, Intercom Systems, Television, Drinking Fountains.

We Also Furnish

Instrument Houses, Mill Offices, Utility Buildings, Enclosures, Building Panels—Ovens, Gonser Patented Positioner and Special Handling Equipment.

JAMES CAMPBELL SMITH, INC.

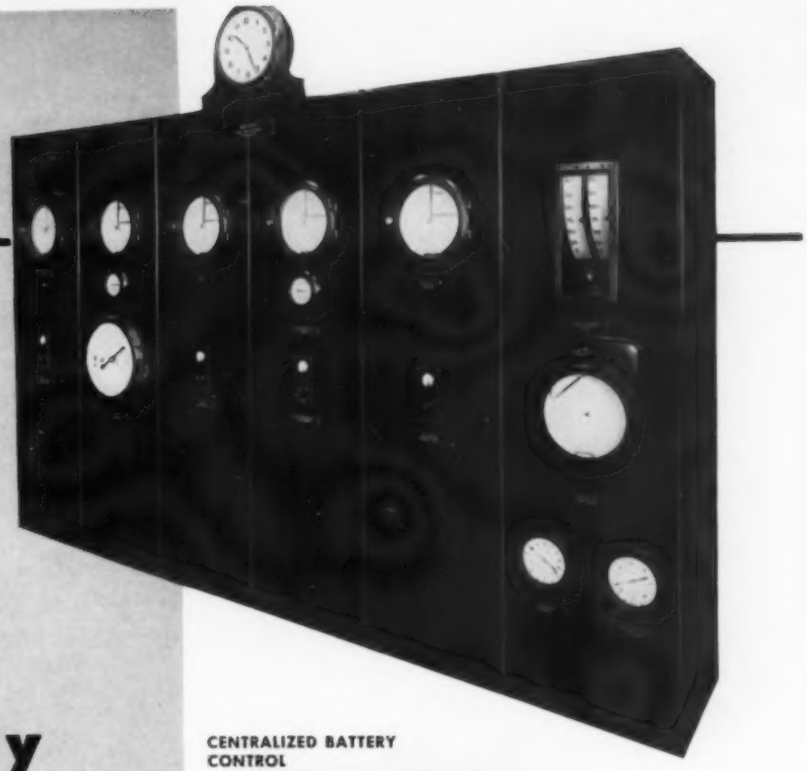
BOX 64 **WILLOUGHBY, OHIO**

ENGINEERS FABRICATORS CONTRACTORS

FOR 35 YEARS

SEND FOR PAMPHLET

Newest REPUBLIC CONTROLS installed on coke battery



CENTRALIZED BATTERY CONTROL at this panel permits an operator to coordinate automatic regulators controlling stack draft, fuel gas volume and pressure and blast furnace gas pressure. Gages and regulators monitor the system.

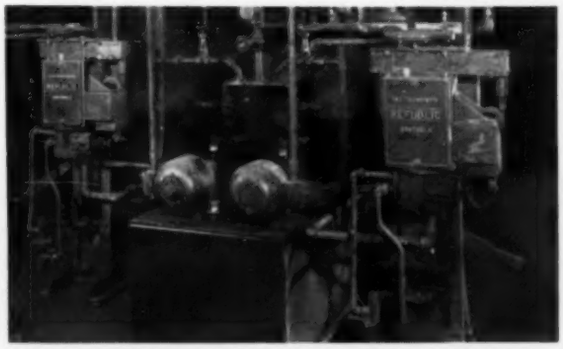
When a new coke battery was added to the coke plant of a mid-western steel mill, Republic electrically controlled hydraulic regulators were installed to control the additional capacity. These new type regulators supplement Republic-Smoot regulators which have been in operation on some of the older batteries for more than 34 years. Dependability, the determining factor in the selection of the new equipment, was more than proven by the performance of the older controls.

The same features—ruggedness and simplicity—which kept these controls in continuous service year after year are embodied in modern Republic Instruments and Controls. That's why Republic equipment remains dependable, regardless of dirt, heat, shocks and vibration. It's also why steel mills such as this one specify Republic, again and again.

GET ALL THE FACTS ABOUT REPUBLIC INSTRUMENTS AND CONTROLS FOR STEEL MILLS

- **ELECTRIC FLOW METERS** for continuous integration and fast transmission of flow information
- **PNEUMATIC ELECTRIC FLOW METERS** for oxygen scarfing and dirty gases
- **LOW PRESSURE RECORDERS** for open hearths, soaking pits, coke ovens, reheating furnaces, smelting furnaces
- **HIGH SPEED POSITIONING OPERATOR** for furnace doors
- **FURNACE PRESSURE REGULATORS**
- **FLOW REGULATORS**
- **BTU TOTALIZERS** for more efficient operation of open hearth furnaces

Write for literature on any of the above



ELECTRICALLY CONTROLLED REGULATORS. The control point of these Republic hydraulic type regulators is set electrically from control panel. In case of failure of hydraulic system, oil trapping valve will lock the regulators in their last position before failure. Electrical failure or accidental shorting of the transmission lines will not cause regulators to shift their control setting.

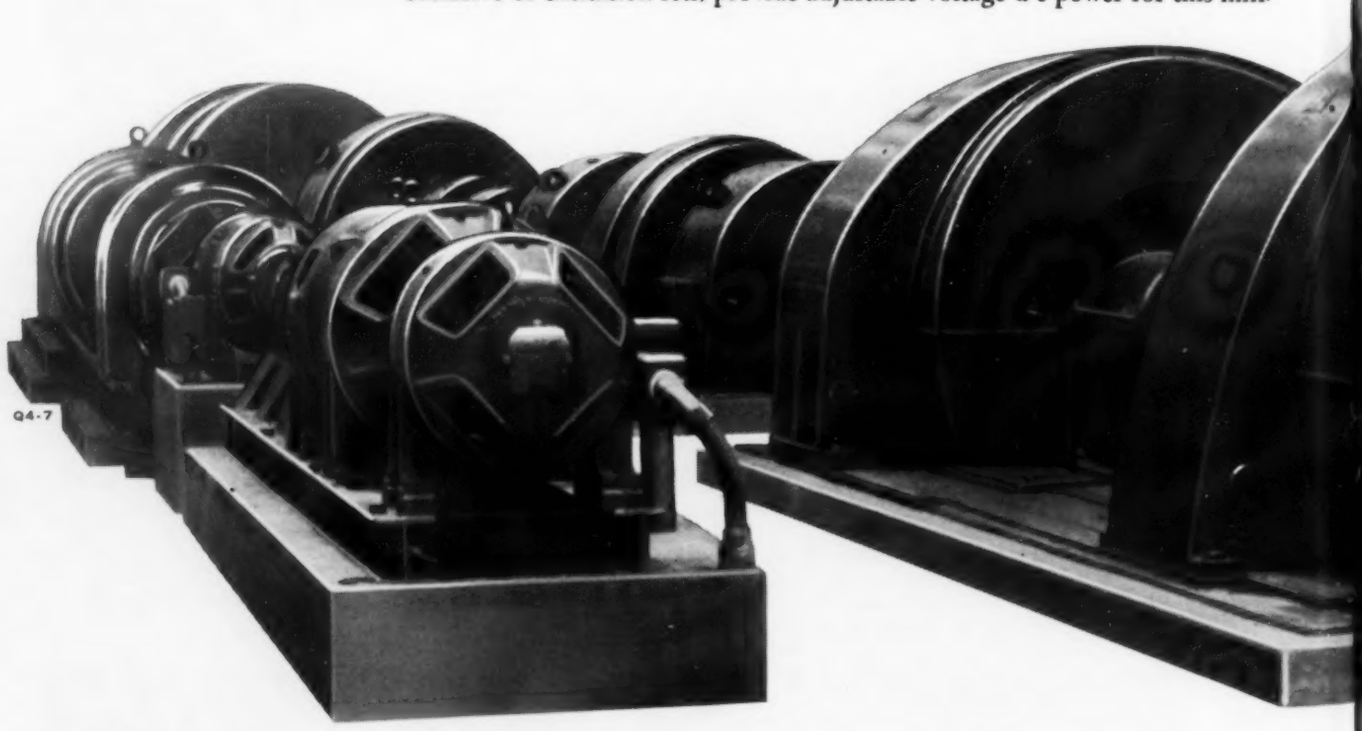
STILL IN SERVICE AFTER 34 YEARS. These old type Republic-Smoot regulators were installed in 1919 when the coke batteries were built. They operate on the force-balance principle, which permits strong, durable construction without loss of accuracy or sensitivity. This same operating principle is used in modern Republic regulators and pneumatic transmitters.

REPUBLIC FLOW METERS CO.

2240 Diversey Parkway, Chicago 47, Illinois

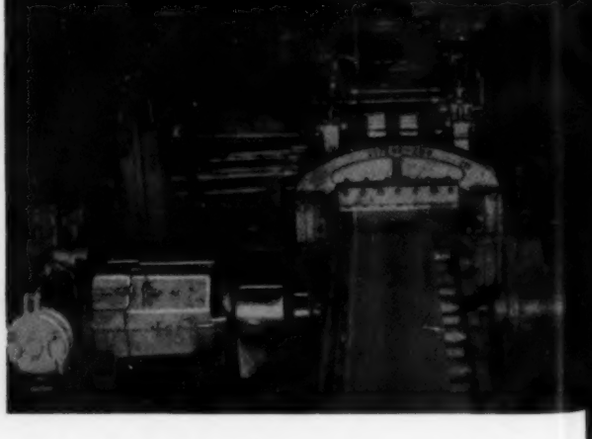
In Lone Star's new pipe mills ...all electric

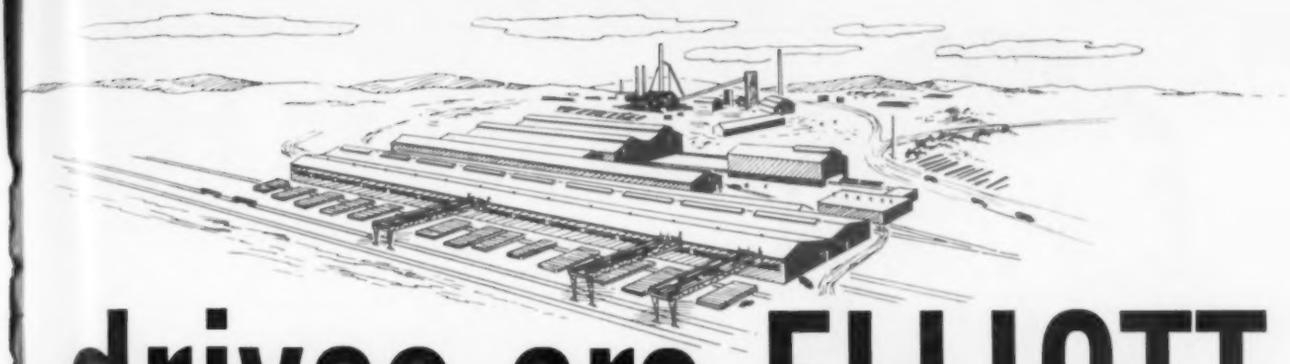
In this group of motor-generator sets, the 4500-hp weld power set for the No. 1 mill is seen in the right foreground. Three additional Elliott m-g sets, exclusive of excitation sets, provide adjustable voltage d-c power for this mill.



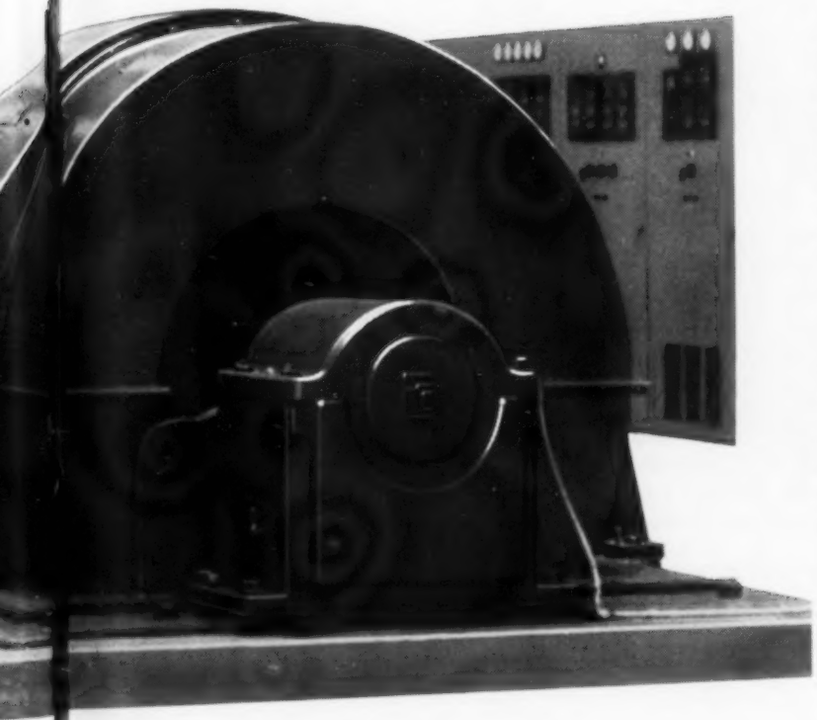
The forming section of the larger mill from the entry end. Drives include eight Elliott Crocker-Wheeler 75-hp, 1150/1440-rpm d-c motors. At right is a 15-hp, 1800-rpm totally-enclosed fan-cooled motor driving hydraulic pump.

Exit end of entry section of the leveller and up-cut shear. An Elliott C-W 50-hp mill motor may be seen at the left.





drives are ELLIOTT



The new plant of Lone Star Steel Company, Lone Star, Texas, is a completely integrated steel mill with its own furnaces, rolling mills and two modern electric resistance weld pipe mills. All electric drives for the pipe mills were supplied by Elliott. Ten Elliott adjustable-voltage d-c generators, totalling nearly 3000 kw, supply the drive power. Two Elliott single-phase alternators, one rated 4000 kva, 2400 volts, 84 cycles, supply the weld power. An Elliott 4500-hp, 13,200-volt synchronous motor drives this larger alternator. More than 500 Elliott a-c and d-c motors are used, these ranging in size from this 4500-hp machine down to small motors, for a total horsepower rating of nearly 15,000.

Elliott steel mill rotating equipment is at home here and in mills everywhere. Elliott design and construction excellence, plus experienced application engineering, makes Elliott a source for your consideration. Ask your nearest Elliott District office for a copy of the new illustrated Bulletin — "Elliott Equipment for the Steel Industry" or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

A view showing four 25-hp, 1150/1440-rpm d-c forming section drive motors on the smaller mill.

The pipe conveyor of the No. 1 mill is driven by a line of Elliott C-W 1-hp, 1750-rpm d-c motors.

This pipe conveyor is driven by a line of Elliott C-W 1-hp, 1800-rpm enclosed induction motors.

"6,000 employees . . ."

A. W. STEUDEL
President
Sherwin-Williams Company

"Naturally, we of Sherwin-Williams give complete endorsement to the Payroll Savings Plan. But we feel that mere approval of a national thrift movement that contributes so much to the personal security of our employees and the economic stability of our country is not enough. In our continuing effort to build employee participation in our Plan, we utilize the personal contacts and enthusiasm of our enrolled Payroll Savers. A recent person-to-person canvass by our employees put a Payroll Savings application blank in the hands of every man and woman in our plants and offices. The result, nearly 6,000 serious savers were added to our Payroll Savings Plan."

The personal interest of executives like Mr. Steudel, and the systematic bond purchases of more than 8,000,000 enrolled Payroll Savers are reflected in the following figures:

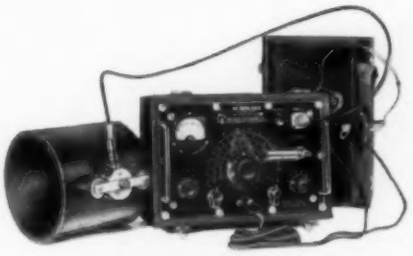
- In March, 1954, purchases of U. S. Savings Bonds, Series E and H, by *individuals* reached $474 million, highest March figure in 9 years—a gain of 20% over March, 1953.
- Purchases of E and H Bonds, by *individuals* during the first quarter of 1954, totaled $1,380 million—the highest for any quarter since 1945.
- The *cash value* of Series E and H Bonds held by *individuals* at the end of March, 1954, was $37 billion, 175 million—the highest in the thirteen year history of the Savings Bond program.
- Payroll Savers are serious savers: over 75% of the amount of Series E Bonds that matured since May, 1951—almost $9 billion—is still being held by individuals under the Treasury's 10 year optional automatic extension plan.
- For the third straight month of 1954, sales of E and H Bonds exceeded maturities and redemptions. The sales excess amounted to $242 million on March 31—the highest first quarter net since 1950.

If employee participation in your Payroll Savings Plan is less than 50%—or if your company does not have a Payroll Savings Plan, get in touch with Savings Bonds Division, U.S. Treasury Department, Washington, D.C. Your State Director, U.S. Treasury Department, will be glad to help you install a Plan and build employee participation.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

IRON AND STEEL ENGINEER

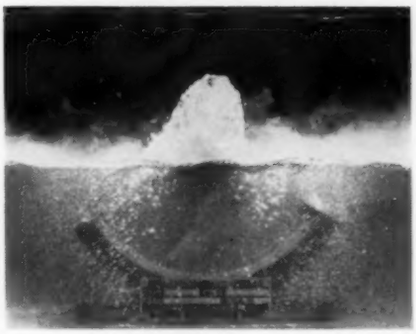
ULTRASONICS



AUDIGAGE®

Portable Thickness Testers

for corrosion inspection and thickness gaging from one side. Ranges from 0.020″ to 4″ or 0.060″ to 12″ of steel or equivalent, accuracies up to 1%.



SONOGEN®

Ultrasonic-Power Generators

for accelerated metal cleaning and degreasing. 500-Watt to 25-Kilowatt, with a variety of transducers.

VIDIGAGE®

Direct-Reading Thickness Tester

with 21″ cathode-ray screen and direct-reading scales. Infinite choice of ranges between 0.010″ and 2.5″ of steel or equivalent. Accuracy from 0.1% to 1.0%, according to application.

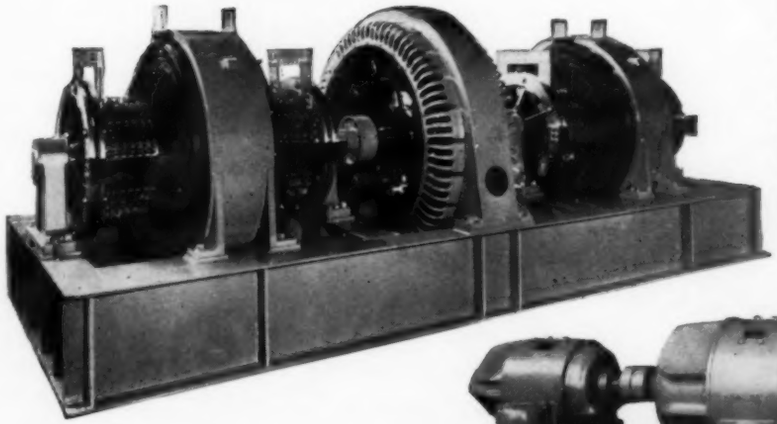
Literature on Request
Department IS

BRANSON INSTRUMENTS, Inc.
430 Fairfield Ave.
Stamford • Conn.
ELECTRONICS • DEVELOPMENT • PRODUCTION

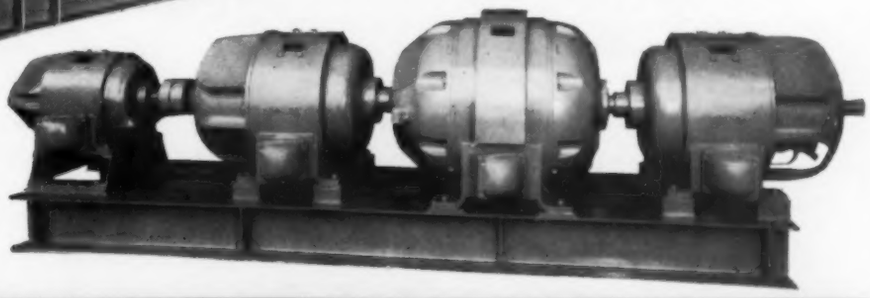
COLUMBIA

MOTOR GENERATORS

● Whether it be for continuous electrolytic tin-plating or electrocleaning lines, or for special power needs, Columbia builds Motor Generator Sets for your individual requirements. They're giving superior, around-the-clock performance in many of the country's leading mills. Illustrated here are typical installations of Columbia generators built to specification.



◀ Two 7500 Ampere 24 volt, 3750 Ampere 48 volt, Separately Excited, Columbia D.C. Generators driven by 600 HP, 1.0PF, 360 RPM Synchronous Motor.

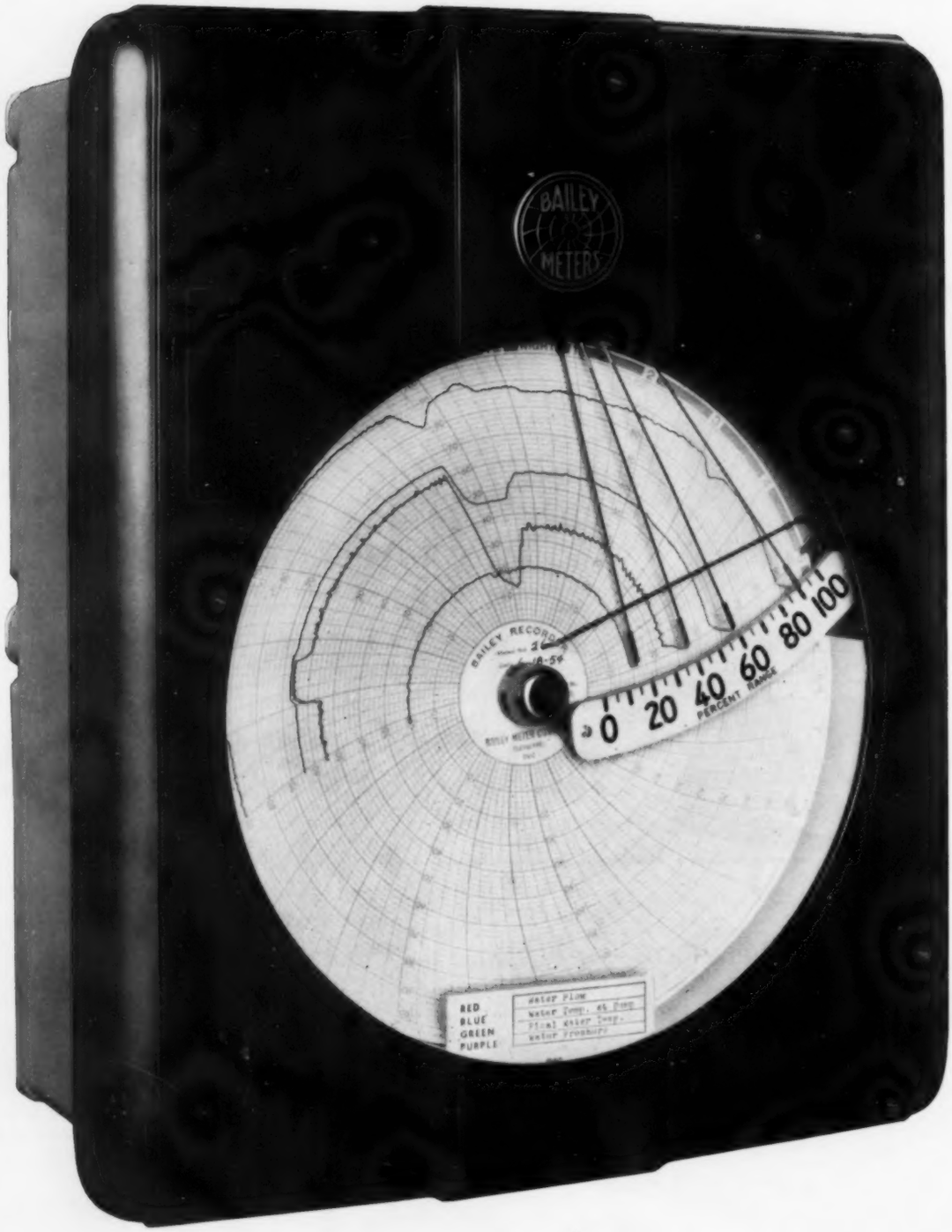


Multi-Unit Columbia Motor Generator Set consisting of two 50 KW, 250 Volt, D. C. Generators, and one 10 KW, 50 Volt, 200 Ampere booster Generator, all driven by 200 HP, 0.8PF, 1200 RPM Synchronous Motor. ▶

COLUMBIA ELECTRIC MFG. COMPANY

4543 Hamilton Avenue — Cleveland 14, Ohio

Announcing the New Bailey



The New Bailey Recorder provides continuous chart records of any four measured variables:

% combustibles	density	flow	pH	ratio	speed
combustion	differential	liquid level	position	smoke density	temperature
conductivity	draft	% oxygen	pressure	specific gravity	vacuum

Recorder for—

Pneumatic and Electric Transmission Systems

Here is a panel-mounted recorder that offers new versatility never before available in a single instrument. Its unique interchangeable-unit design permits recording up to four measured variables, regardless of their nature or the location at which they are measured.

Individual plug-in type pneumatic or electronic receivers—and corresponding integrators—are interchangeable in the four identical frame-slots, permitting any combination of four pneumatic or electronic signal receivers, *or any two receivers and their two integrators.*

For the first time you can record four telemetered measurements on a single 12-inch circular chart—with a minimum of first cost and installation expense, and a maximum of operating economy. Low cost multi-purpose components permit fast and easy adaptation to new or changed process cycles.

Visit the Bailey Booth at the Iron & Steel Show
Check These Outstanding Advantages

Extreme Flexibility of Application is provided through the use of pre-calibrated plug-in type units—pneumatic or electronic—to record any measurable variables, in any combination. For example, you can "plug-in" pneumatic receivers along with electronic receivers to record up to a total of four variables on the same chart. Or your recorder casing can accommodate two integrators and their two corresponding recording receivers for rate of flow.

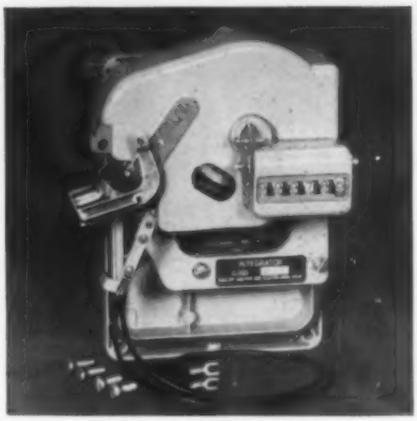
Faster, Easier Servicing of instruments is possible because of the new, sealed ink sacs and capillary pens. Under normal conditions ink sacs need be replaced only once each year. There is no day-to-day inking of pens.

Faster, Easier Ordering from Stock results from the unique standardized unit design. You can select any combination of recording receivers to fit your needs, by reference to simplified catalog specifications, and receive shipment without the delays ordinarily resulting from custom assembly. Complete interchangeability of plug-in type components simplifies stocking of spare units.

G34-2

Write for complete specifications—use handy coupon below

Plug-in type pneumatic receiver



Plug-in type integrator

Plug-in type electronic receiver

BAILEY
METER COMPANY
1047 IVANHOE ROAD
CLEVELAND 10, OHIO
Controls for Power and Process

BAILEY METERS

COMBUSTION
TEMPERATURE
PRESSURE
GAS ANALYSIS
LEVEL
RATIO
FLOW

Bailey Meter Company
1047 Ivanhoe Rd., Cleveland 10, Ohio

Please send me product specifications on the new Bailey Recorder, as follows:

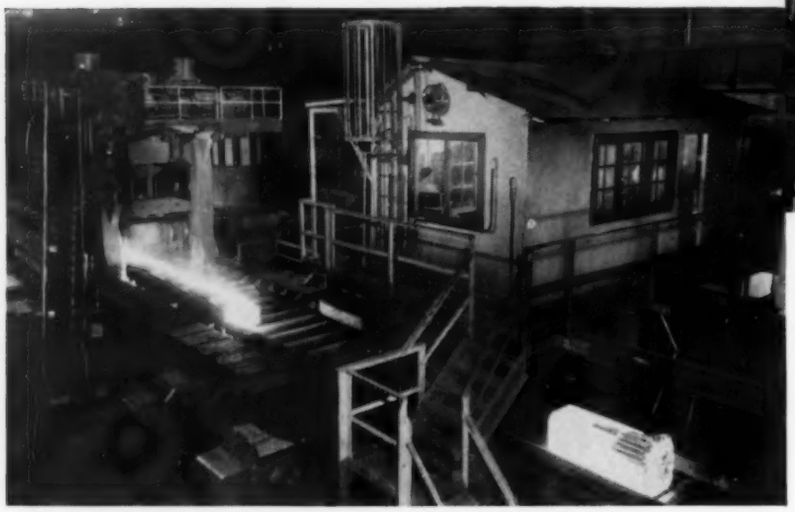
☐ With Pneumatic Receivers - Spec. P11-5
☐ With Electronic and Pneumatic Receivers —Spec. E12-5

Name_____
Title_____
Company_____
Street and Number_____
City_____ Zone____ State_____

Trabon

AUTOMATICALLY LUBRICATES YOUNGSTOWN MILL

.....and cuts MAINTENANCE *to the bone!*



After the first four months of operation, the only maintenance on TRABON'S automatic lubrication system, recently installed on the Youngstown Sheet & Tube Company's 44" blooming and slabbing mill, was the replacement of two hoses in an unusually hot spot.

Bearings were in good shape after the rolling of 238,100 tons. Everyone was pleased with the production record.

We were, too, because this installation proved once again that a Trabon system can deliver just the right amount of oil or grease at just the right time in exactly the right place.

And a Trabon system does this job under the worst possible operating conditions . . . dirt, steam, ice, heat . . . *positively!*

What's YOUR lubrication problem? Write for our current detailed literature.

Pertinent FACTS

- Automatic oil system lubricates screws, breaker blocks and nuts.
- Automatic grease system lubricates roll necks and chuck slides; front and rear table drives, manipulator and feed roll bearings in mill housing.
- All pumps in cellar.
- Control boxes in engine room.
- Lights and warning horns included.

TRABON automatic lubrication has a BEARING on the subject of production

Trabon ENGINEERING CORPORATION

1814 E. 40th STREET • CLEVELAND 3, OHIO

Oil and Grease Systems

Equipment News...

THICKNESS GAGE

▲ A new device for automatically regulating the thickness of metallic strip leaving cold reduction mills will be exhibited in Booth Nos. 68 and 69 by the Sheffield Corp., at the Iron and Steel Exposition, Cleveland, Ohio, September 28, 29, 30 and October 1, 1954.

The new sizing control has been designed to operate in conjunction with Sheffield Measuray, and X-ray Thickness Gage. In use, the operator simply sets the dials on the Measuray control cabinet to the required thickness.

A feature of the control is the automatic regulation of the screwdowns on the mill. Whenever the strip thickness varies from that set by the operator, the screwdowns on the mill will either raise or lower depending on whether the strip is too thin or too thick. A part of the system includes controls that anticipate whether the screwdowns need adjusting either up or down. This feature eliminates hunting and/or over correction, thereby holding closer tolerances than ever before.

PNEUMATIC RELAY

▲ A pneumatic relay that can multiply two different input pressures to provide a proportional outgoing pressure has been announced by Minneapolis-Honeywell Regulator Co.

The new device, known as a Tel-O-Set automatic ratio relay, was developed primarily for applications in the chemical, petroleum and metal processing industries.

The relay receives two pressure signals of from 3 to 15 psi each and transmits an output pressure that is proportional to the primary input pressure. The factor of proportionality, or ratio, between output and input is adjusted by the second input pressure. The maximum range of ratios is 0 to 2.0, which corresponds to the 3 to 15 psi change in ratio setting pressure. However, the ratio span may be changed to any desired value, within this range, by means of internal adjustment screws.

The new pneumatic relay also features limit stops on the output pressure; suppression adjustments for all pressures; adjustable pulsation dampers on both input pressures, and a high-capacity, non-bleed pilot valve capable of handling large loads without auxiliary boosters. Separate gages indicate each input and the output pressure.

MAGNETIC DISC BRAKE

▲ The latest addition to their new line of re-designed magnetic disc brakes is announced by Stearns Magnetic, Inc. This unit, the H-70 magnetic disc brake is for use on re-rated 3-20 hp motors, and is available in maximum torque ratings of 10, 15, 25, 35, 50, 70, 75 and 105 lb ft. The brake is designed to mount on new frame sizes 213 through 286 and is up to $1\frac{5}{16}$ in. shorter than previous brakes.

A new feature of the H-70 brake is the manual release-automatic reset wear indicator recently introduced on the new Stearns brake line. The spring set solenoid released brake is

supplied for either horizontal and vertical motor mounting or independent floor mounting and is available with either standard or dust-tight, waterproof enclosure.

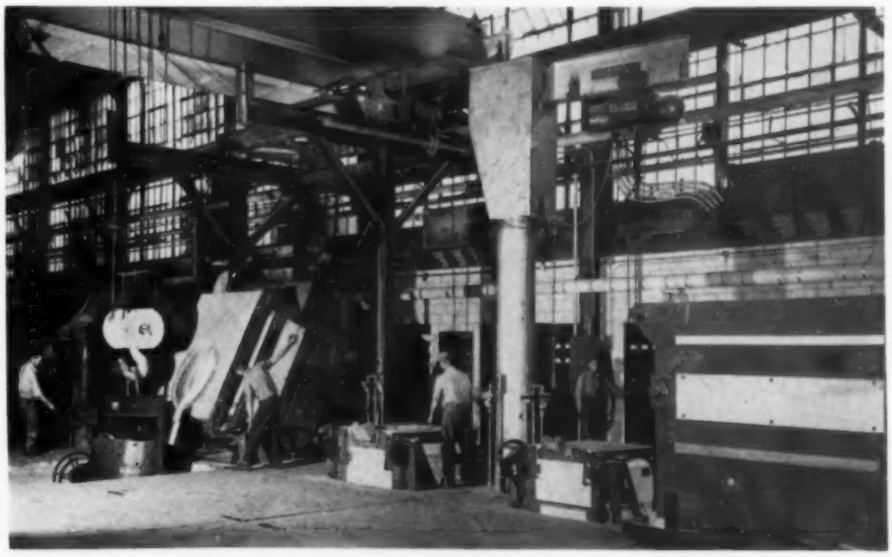
SPRING-DRIVEN REEL

▲ The type WB Gleason Reel is a spring-driven reel of unique design which takes up and pays out electric cords and cables without contacts, collector rings or other electrical parts. There is no twisting of cord or cable and explosion hazards are eliminated.

"Window shade" action is provided by locking dogs. The reels are

NEW FURNACES PRODUCE WIDE RANGE OF CASTINGS

This is one of the high frequency melting furnaces now being produced by the Sandusky Foundry and Machine Co., Sandusky, Ohio. These units make possible the production of centrifugual castings in a wide range of both ferrous and non-ferrous compositions and alloys.



You get all 4
— Safety
— Economy
— Dependability
— Long Life

with **TAYLOR MADE**

the only complete line of

ALLOY STEEL CHAIN

because...

● Taylor Made Alloy Steel Chain has twice the tensile strength (125,000 lbs. P.S.I.) of wrought iron chain (48,000 lbs. P.S.I.)!

● This famous nationally advertised chain is heat-treated—never requires annealing!

● It has tremendous resistance to shock, grain-growth and work-hardness at all temperatures!

● All slings are furnished with amazing new Taylor Made Alloy Steel Tayco Hooks!

● Rings, joiner links and other sling attachments are of the same analysis, heat-treated alloy steel as the chain.

S. G. TAYLOR CHAIN CO., Hammond, Ind.

Send coupon for free folder

S. G. Taylor Chain Co.
Dept. 5 Hammond, Indiana
Rush free copy of Booklet No. 12C giving all the facts and specifications on Taylor Made Alloy Steel Chain!

Name_____

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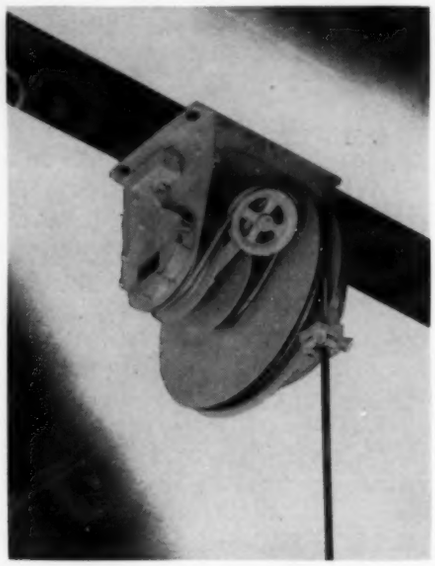
TAYLOR MADE
A GREAT NAME IN
Chain SINCE 1873

hung from overhead beams near the hearths and the pyrometer lead can be quickly pulled down, held without tension while readings are taken, and then released and automatically rewound. The lead is kept off of the

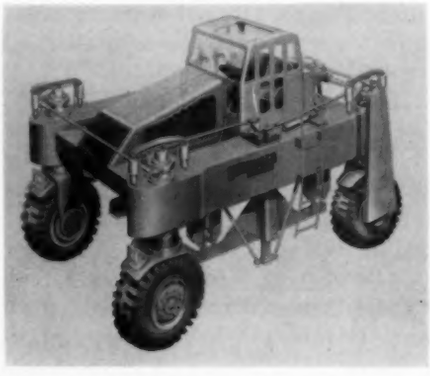


floor and out of the way, yet the pyrometer head is instantly and conveniently accessible.

Positive true readings are assured as the varying resistance and impedance of sliding contacts, twisting of the cord and partial breakage of the lead from mill floor damage are prevented.

MATERIAL CARRIER

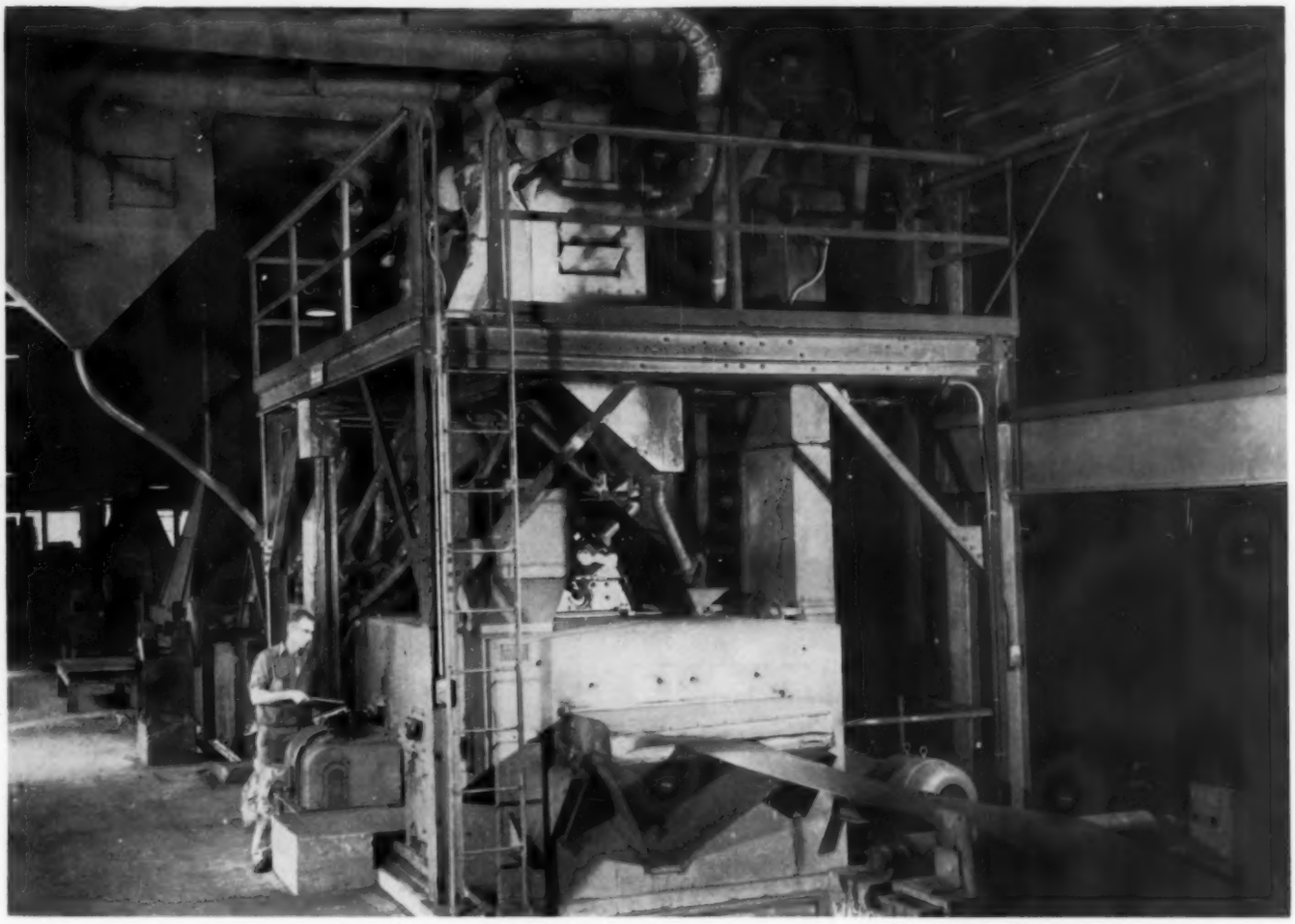
▲Engineered primarily for use by the steel industry, the new Gerlinger SC-50 Material Carrier has a capacity of 50,000 lb. Of swinging shoe lifting type, the SC-50's hoist mecha-



nism is fully hydraulic, fully equalized, actuated by double-acting, self-centering control valves and balanced relief valves.

This model is available in six standard sizes and incorporates many exclusive Gerlinger features.

pioneering developments keep WHEELABRATOR® first in blast cleaning



Steel Strip Descaled without Scale Breaking

More uniform, better quality strip at lower cost with Wheelabrator mechanical cleaning

Advantages of Airless Wheelabrator mechanical cleaning at Washington Steel Corp. in removing scale from stainless steel strip is summarized by Mr. T. A. Fitch, President, as follows: "The Wheelabrator makes short work of the heavy scale with none of the rolled-in scale, coil digs, slivers, etc. so common to cold-rolled methods of scale breaking. It is faster, more efficient, and does a better job quality-wise."

Prior to the installation of the Wheelabrator in its strand annealing and pickling line, Washington bought annealed and pickled coils for cold rolling and finishing. With the Wheelabrator they are obtaining better quality descaling at production line speeds plus a reduction in manpower and reduced use of pickling acid.

Mechanical descaling of steel strip with the Wheelabrator as an integral unit in steel cleaning lines is also returning impressive savings for other steel producers and fabricators alike. Rome Cable Corp., for example, selected Wheelabrating for descaling steel strip because it was the only process that would economically remove surface scale and permit the rest of the plant to maintain its high production without requiring a major portion of its plant area.

Wherever steel is processed in large quantities, the possibilities for saving money with a Wheelabrator are tremendous. Write today for full details.

Bulletin 894 tells how to descale steel strip at high speeds and low cost. Send for your copy today.

American
WHEELABRATOR & EQUIPMENT CORP.
396 S. Byrkit St., Mishawaka, Ind.

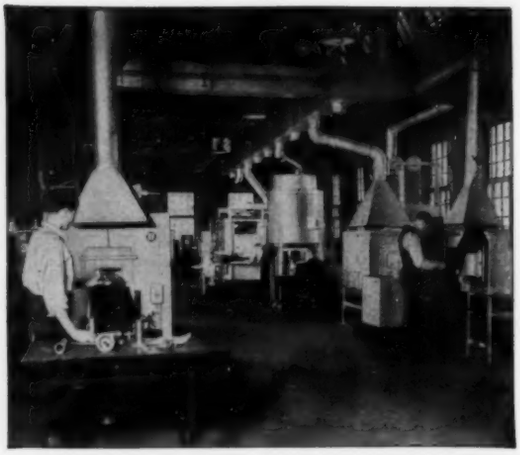
Wheelabrator®
AIRLESS BLAST CLEANING

RESEARCH DEPARTMENT

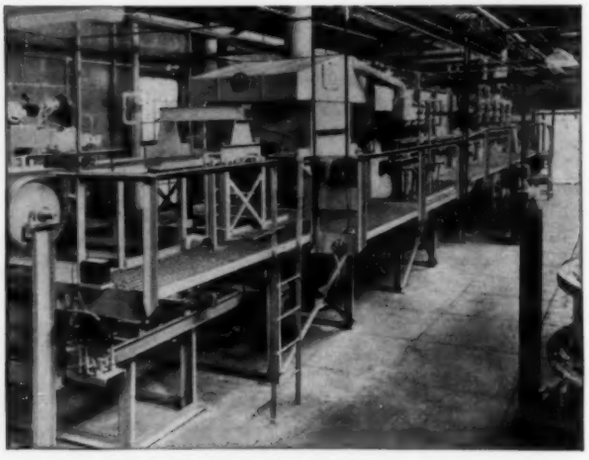
available to

PRODUCERS and PROCESSORS

of metals and metal products



General view of the research department showing several of the continuous and batch type experimental furnaces.



View of combination gas-fired and electric continuous furnace equipped with flame preheating burn-off or oxidizing section and controlled heating, soaking and cooling zones, for producing various surface conditions on strip.

● The EF research department is equipped with gas-fired, oil-fired and electrically heated continuous and batch units including,— continuous wire mesh furnaces;— endothermic and exothermic special atmosphere generators; — forced circulation bell furnaces; — a continuous roller hearth furnace for treating commercial widths of ferrous and non-ferrous strip; — and other equipment.

Consequently, — from test runs — we can determine accurately the combination of temperature, time cycle, atmosphere and other factors needed to produce the exactly desired results, — assuring — in advance — the efficient performance of EF furnaces *fully up to specifications.*

Many large companies have drawn liberally upon this department in developing new products, and new techniques. Our facilities are available to YOU also — for YOUR research or development work, either gratis or for a moderate fee, depending upon the nature of the experiment. We will be glad to schedule time for your technicians.

Write today for our 12 page booklet, "Research Facilities." It describes the equipment we can place at your disposal.

Direct gas-fired forced circulation bell type furnace for processing wire, rod, strip and other products.

Gas-Fired, Oil-Fired and Electric Furnaces

for any Process, Product or Production

THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R. *Salem - Ohio*

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada

VACUUM FURNACE

This 1000-lb. vacuum furnace for melting and casting high-temperature alloys for jet engine turbine blades has just been installed at Utica Drop Forge & Tool Corp., Utica, N. Y. It was designed and built by F. J. Stokes Machine Co.; Philadelphia, Pa.

EXTRUSION PRESS

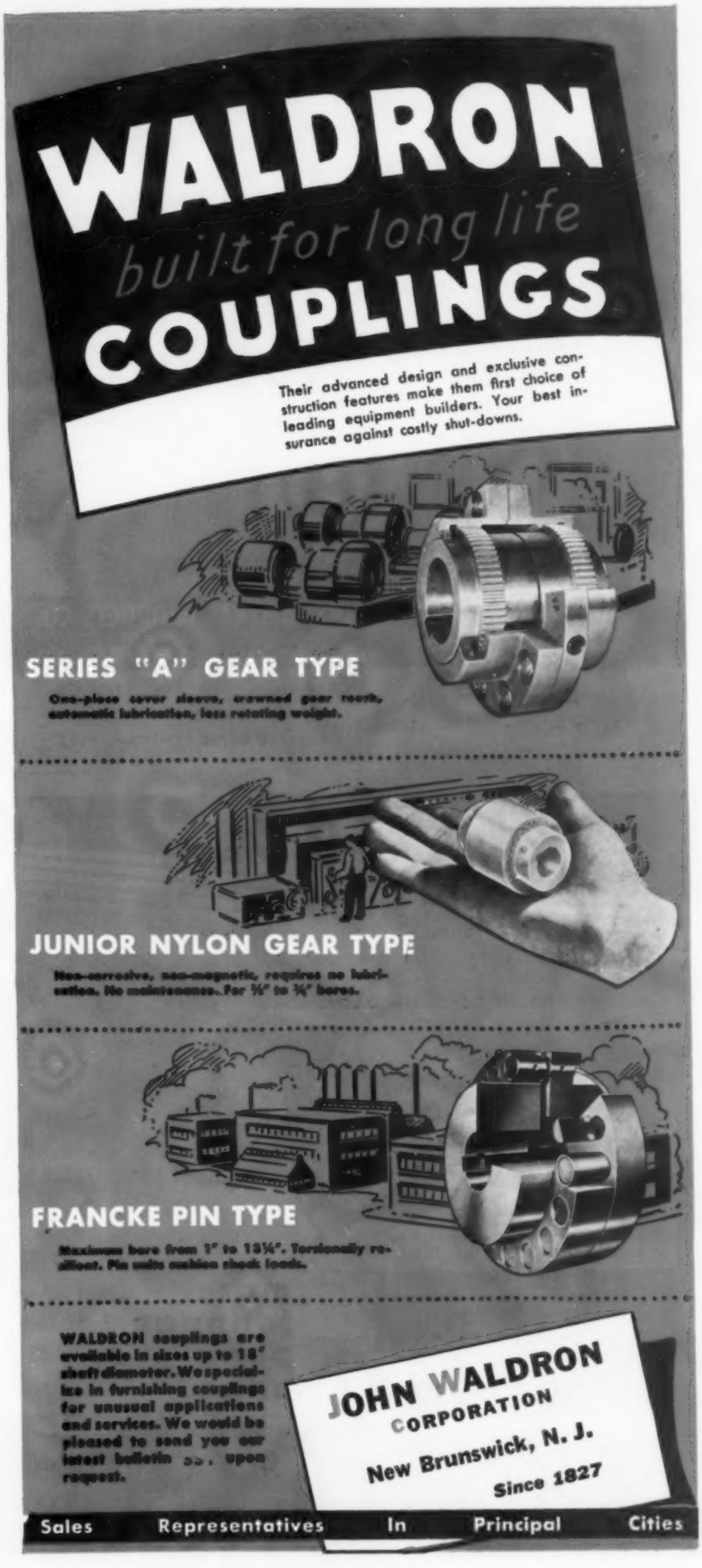
▲ To introduce the first of a new line of extrusion presses a series of demonstrations have been held recently at Sutton Engineering Co. Actual extrusions of various alloys of aluminum, brass and copper shapes, bars and tubes have been made under normal operating conditions. Representatives of leading firms in both the ferrous and non-ferrous metal industries have attended.

The new press, 750-ton horizontal, direct-powered unit, offers extra fast cycling; positive billet loading; easy die change, heavy-duty shear of extra high capacity; sensitive control of the main ram; and other important features. Design and manufacture have taken over a year during which time a survey of extruders was made to determine wants and needs.

SHEARING UNIT

▲ Designed for production shearing of steel plate in sizes up to 8 ft long x 1½ in. thick is a steelweld shear built by the Cleveland Crane & Engineering Co.

The shear is ruggedly constructed with end housings, crown and bed welded into a solid one-piece unit. The end housings are provided with heavy, deep throat forgings that


WALDRON
built for long life
COUPLINGS
Their advanced design and exclusive construction features make them first choice of leading equipment builders. Your best insurance against costly shut-downs.
SERIES "A" GEAR TYPE
One-piece cover sleeve, crowned gear teeth, automatic lubrication, less rotating weight.
JUNIOR NYLON GEAR TYPE
Non-corrosive, non-magnetic, requires no lubrication. No maintenance. For ⅛" to ¾" bores.
FRANCKE PIN TYPE
Maximum bore from 1" to 13¼". Torsionally resilient. Pin units cushion shock loads.
WALDRON couplings are available in sizes up to 18" shaft diameter. We specialize in furnishing couplings for unusual applications and services. We would be pleased to send you our latest bulletin 55, upon request.
JOHN WALDRON
CORPORATION
New Brunswick, N. J.
Since 1827
Sales Representatives In Principal Cities

greatly add to the frame strength and also increase the shearing possibilities, especially for certain angle cuts and slitting.

The machine operates on the pivoted-blade principle. The blade travels in a circular path without the use of guides and slides common with guillotine-type shears, thus eliminating a principal source of wear and shearing inaccuracies.

An electric foot switch is used for operation of the shear. This can be moved about the floor to wherever most convenient, reducing operator fatigue.

The clutch and brake unit is air-operated and designed with a low-inertia principle that permits long continuous runs of shearing without overheating. The unit is unusually fast acting and provides quick, positive clutching and braking with very little slippage. Thus wear and heat are reduced to a minimum. The design permits easy accessibility for adjustment and maintenance.

The operating speed is 22 strokes per minute. Adjustments are provided to enable slitting and notching. Main and eccentric bearings are lubricated by an automatic oiler system.

CRADLE ATTACHMENT

▲ The Elwell-Parker Electric Co. has developed a cradle attachment for their fork trucks which permits reaching into the pile to pick up rolls not ordinarily accessible when using standard forks.

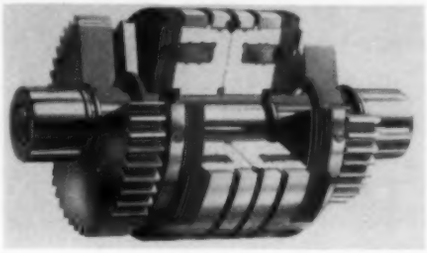
In operation, a rod or bar is inserted through the core of the roll extending slightly from each end. Notches on the ends of the cradle arms engage the rod to pick up the load. To deposit the load the truck's elevator mechanism is lowered until the load rests on the floor, free of the arms. Various arm lengths may be designed depending on the size and weight of the load and the reach desired.

CLUTCH UNIT

▲ A new design in electromagnetic clutches is now available from I-T-E Circuit Breaker Co. This clutch fits the requirements of transmission employing constant mesh gearing. The

clutch design provides constant horsepower output, quiet operation and rapid speed change.

The company states that safe positive operation is assured because the clutch is controlled by a 24 volt DC



circuit and no field adjustment of the torque value of the clutch can be made. Maintenance is reduced to a minimum since the I-T-E Electro Clutch is self compensating and no adjustment for wear of the clutch plates is ever required.

STRAPPING REEL

▲ Manufactured by A. J. Gerrard & Co. is a new electrically operated strapping reel, designed to save time and work in dispensing and cutting heavy duty strapping.

Made to efficiently handle any size strapping from ¾-in. x .035-in. to 2-in. x .050-in., the Model 430 Bulkbinder electric strapping reel is ideal for use in steel mills, warehouses, shipping docks, and other locations where strapping is cut to length. It is built to stand up under heavy usage, and can be moved about on an ordinary hand truck.

One man can control the entire unreeling and cutting operation without waste motion. The Reel operates on 110-volt AC current. Other special electrical requirements can be made to order.

BRACKET UNIT

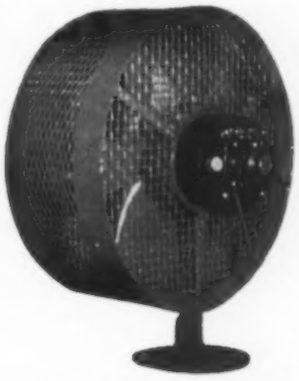
▲ The Thompson Electric Co. announced the availability of "Servisafe" wall and wood pole brackets which are designed to permit safe, efficient ground-level luminaire servicing. Incorporating the patented Thompson disconnecting and lowering hanger mechanism, these units completely eliminate climbing and electrical hazards. In addition, unit design provides for almost unlimited range of application and permits greater luminaire mounting heights for improved area illumination.

To lower a luminaire mounted on the bracket, workman opens tamperproof lockbox mounted near wall or pole base and attaches a separate handline to operating cable. He then disconnects the two hanger members with a slow pull and quick release on handline and lowers lighting fixture to ground-level. Because the live contacts remain in fixed-position upper member, lowered luminaire is "dead" and presents no electrical hazards. After fixture is serviced, it is quickly returned to operating position and automatically re-seated by means of handline.

Supplied in complete packages ready for wiring and erecting, these units can be used with standard pendant and flood type luminaries. Mast arms ranging from two to 12 ft, in two-foot increments, are available.

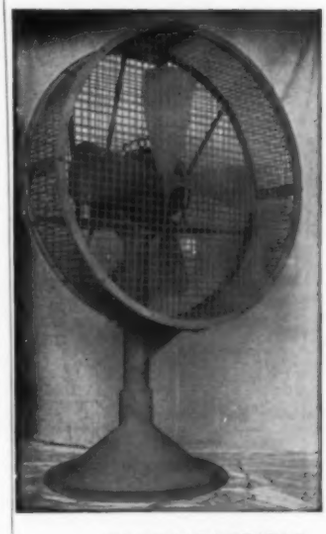
(*Please turn to page 311*)

IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS



TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

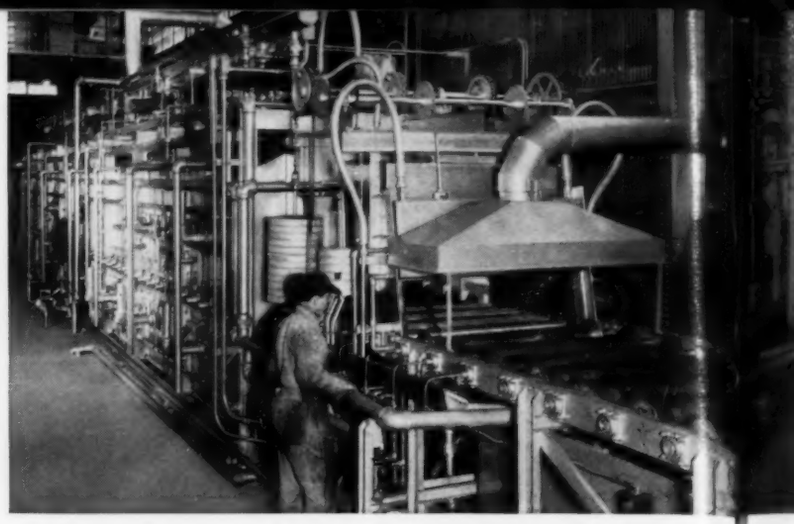
All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY

245 MAIN ST. HARMONY, PA.

continuous processing

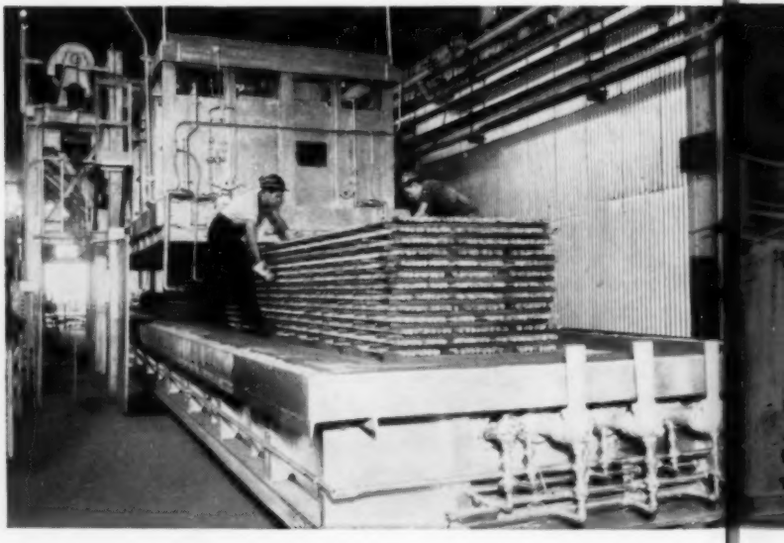


'Surface' roller hearth furnace for continuous carbon restoration-annealing of bars and coils.

'Surface' atmosphere equipment

'Surface' lift cover car bottom furnace used for batch carbon restoration-annealing of bar stock.

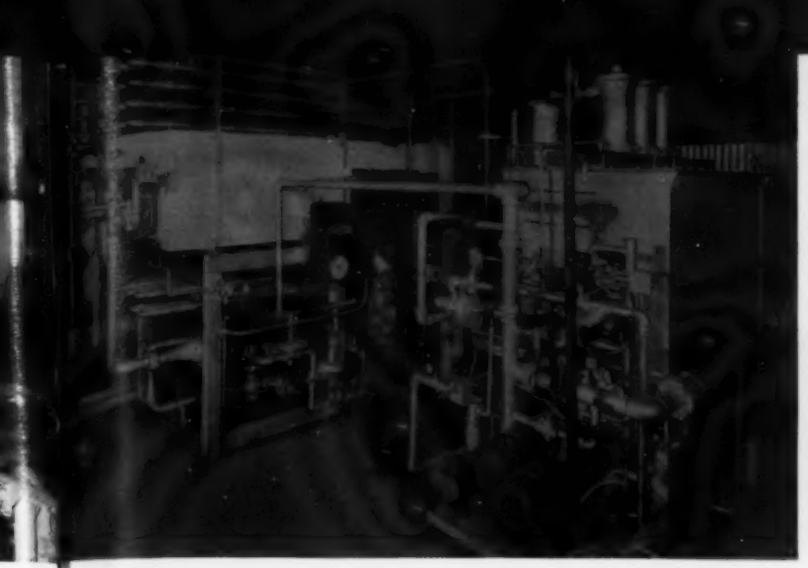
batch processing



Here are a couple of graphic reminders that Surface Combustion atmosphere equipment helps meet today's demands for top quality steel.

These cases repeat a familiar story in the steel industry: a steel processor wants to improve the metallurgical qualities of his stock—'Surface' equipment meets, and frequently exceeds, his specifications.

In your current program for improving the marketability of your products, look to 'Surface' to provide the right atmosphere for easier sales.

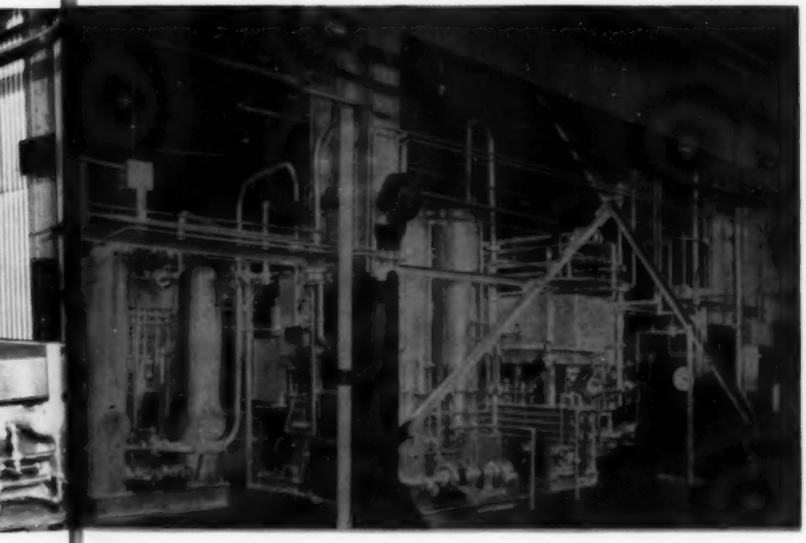


'Surface' atmosphere generators for this installation. RX unit in the foreground, NX unit in the background.

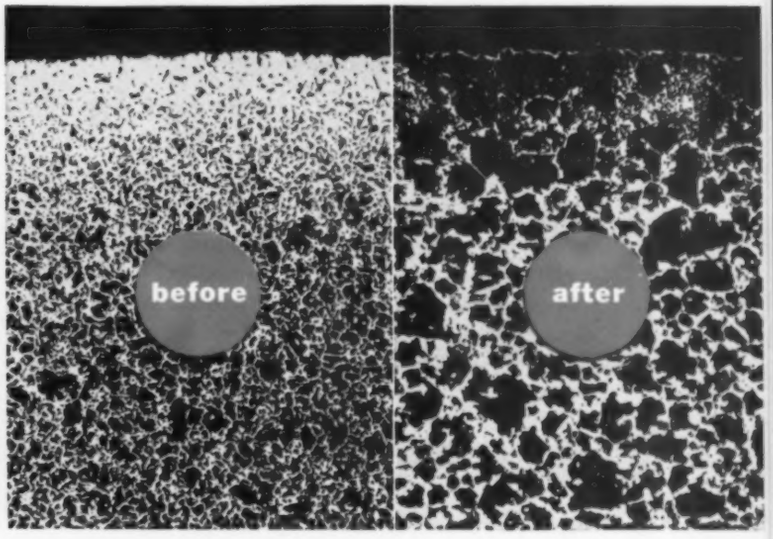
Before and after photomicrographs, Carbon steel AISI C1050. The results: carbon restored to the decarburized skin; steel which reduces the customer's machining costs, eliminates rejects.

makes steel easier to sell

'Surface' atmosphere generators next to the furnace. NX generators and coolers in the foreground, RX generator and dew point recorder in the background.



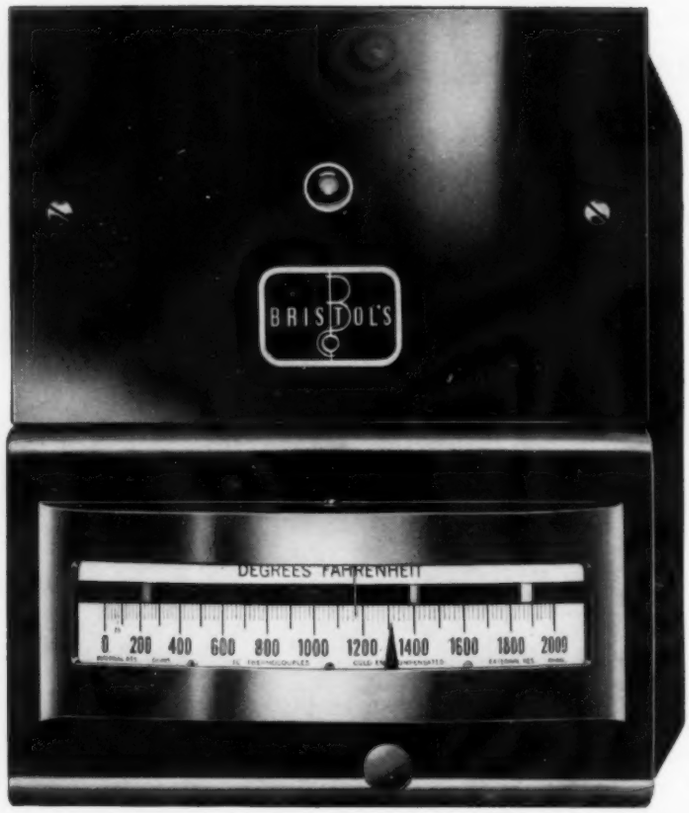
Before and after photomicrographs, C-1045, 1 1/16" round, coarse grain, 75x, 4% Nital etch. The results: carbon restored to the decarburized skin; steel that sells and opens new markets for the processor.



Surface
STEEL MILL FURNACES

SURFACE COMBUSTION CORPORATION · TOLEDO 1, OHIO

what's new at BRISTOL...



SERIES 536 INDICATING

Free-Vane® Electronic Pyrometer Controllers

A new development in automatic temperature control

featuring...

● **A UNIQUE ELECTRONIC CONTROL SYSTEM, which gives a new quality of automatic control.** The controller is extremely stable, rugged, and sensitive. Very minute changes in the measured quantity at the control point (less than 0.003" on the scale) closes or opens the Thyratron-operated relay with positive trigger action, making it impossible for the relay to flutter or chatter. Control action is unaffected by changes in ambient temperature, line voltage, or wide variations in tube characteristics.

● **A NEW MILLIVOLTMETER MECHANISM for greater accuracy.** High-torque, rugged, jeweled mechanism has 30 ohm coil, Alnico 5 magnet, a sensitivity of 15 ohms per millivolt. All ranges are critically or over damped.

● **OUTSTANDING MECHANICAL DESIGN for easy installation, interchangeability, and simplified servicing.** All units, including pyrometer unit, electronic control unit, and proportional-input unit are separate. The electronic control and proportional-input units plug in. No routine adjusting or attention needed. Series 536 Indicating Free-Vane Electronic Pyrometer Controllers are available as thermocouple and radiation pyrometers in ranges up to 4000° F. for L, H, LH, HOH, and LNH control and for L and H with proportional input control. Write for Bulletin P1248. The Bristol Company, 123 Bristol Road, Waterbury 20, Connecticut. 3.10

LOOK FOR OUTSTANDING NEW DEVELOPMENTS FROM BRISTOL

BRISTOL

THE DEPENDABLE GUIDEPOST OF INDUSTRY

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

(*Continued from page 307*)

Guy rod brace assemblies are supplied with units having six ft or longer mast arms, and may be ordered separately for shorter arm units if desired.

GAS-INSULATED UNITS

▲ A joint project of the General Electric Co. and the Consolidated Edison Co. of New York, involves the first application of a high-dielectric gaseous insulation to high voltage power transformers.

According to W. S. Ginn, general manager of G.E.'s power transformer department, it foretells the eventual displacement of oil- and askaral-filled transformer construction by gas-filled, dry-type construction. The new dry-type units filled with sulphur hexafluoride gas will be suitable for both indoor and outdoor installation.

Two of the new type units, rated 2000 kva, 69 kv, are now on the General Electric drawing boards. When completed, the transformers will be operated for field test experience by Consolidated Edison.

With the benefit of field testing, the new gas-filled construction can conceivably be extended to considerably higher voltages, Mr. Ginn said.

Because pressurized gas is a much poorer transmitter of sound than liquid, the new transformers are expected to have improved sound characteristics compared with those manufactured currently. Furthermore, the omission of oil and the reduced core and coil dimensions which may result from the new gaseous insulation should produce transformers which are lighter in weight than similarly rated units of conventional design, the general manager added.

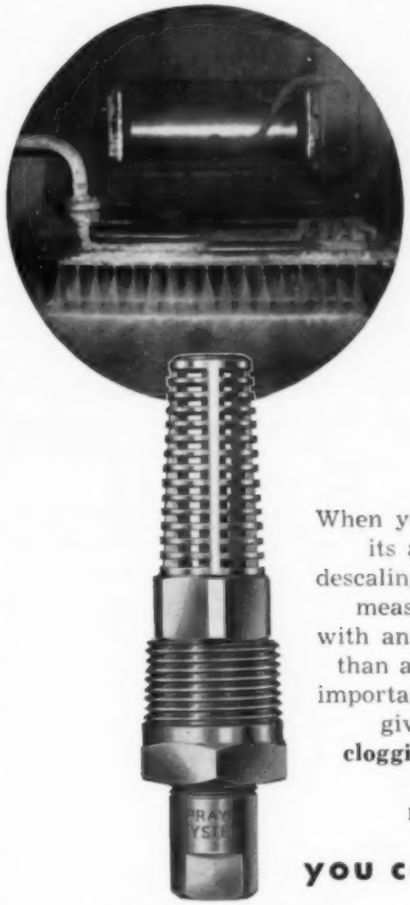
IMPROVED WIRING

▲ New design feature of the control units of all-electric adjustable-speed V*S drives manufactured by the Reliance Electric and Engineering Co. is "channel wiring."

This innovation involves two new approaches to basic principles: first—leading the wires across the surface of the control panels through protective "channels"; second—coding the wires, by number and color, and no longer showing the actual wires on the diagrams.

The result is added protection for the panel wiring, simplification of wiring diagrams, and easier alteration for possible future changes of drive functions. Maintenance time is reduced by the simplified wiring arrangement. Under the old method, panel wiring in the control unit consisted of solid wire placed flat against the panel, with wires laid parallel and held in place by metal clips. While neat in appearance, if the clips were removed to make changes the result was often a difficult-to-handle collection of loose wires.

Under the new system the wires are carried in duct-like channels which have perforated sides for the exit of each wire to its proper destination. Neat and compact, the channels provide both protection and guidance and help to minimize time involved in wiring changes or additions. Fur-



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Stop sparking — help commutation — prolong brush life. For all sizes of commutators.

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thermore, each wire is coded by number and color. Therefore, the wiring diagrams need no longer show the actual path of the wires. They show only the numbered terminals.

This makes wiring diagrams far simpler than before. With use of the old method, the course of each wire was indicated on the diagram. The new "channel wiring" diagrams show connections only on the diagram itself, and coding is given in a wiring table. Channel wiring diagrams are easier to follow than the old style, since it is much simpler to locate a connection by lead number and color code than by trying to trace the course of the actual wire itself. Changes in channel wiring diagrams require only code changes or additions on the wiring table, rather than design and layout work to fill in the actual path of the wires.

CONTROL UNIT

▲ The small and compact Model 292 Series Wheelco Capacitrol has been designed for accurate indicating and instantaneous control in the process industries.

This rugged, reliable and easy to service instrument uses plug-in components. Both the temperature measuring system and the control chassis are of plug-in design. This feature permits quick removal of either the measuring system or control chassis for easy replacement and servicing without disturbing the instrument or external wiring.

The series provides for flexible "on the job" adjustments. The balancing adjustment for tuning the alignment index and indicating pointer to exact coincidence, plus adjustment of anticipatory action cycle time (on Model 292C), along with control setting are all front accessible.

Thermocouple Break Protection, that shuts off the fuel supply in case of thermocouple or lead wire failure, can be supplied as an extra feature. The inexpensive vacuum tube used in the control chassis may be purchased from any electronic supply house.

DECALS

▲ Three new types of heat resistant decals for industrial application are approved by the Meyercord Co., the

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We design them FOR....

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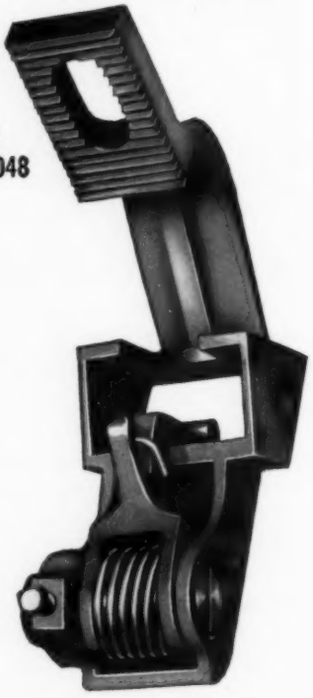

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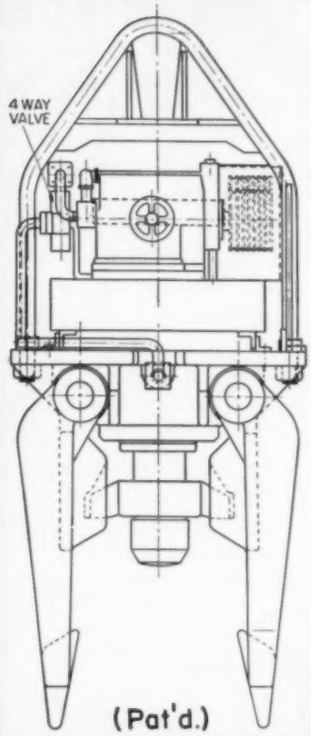

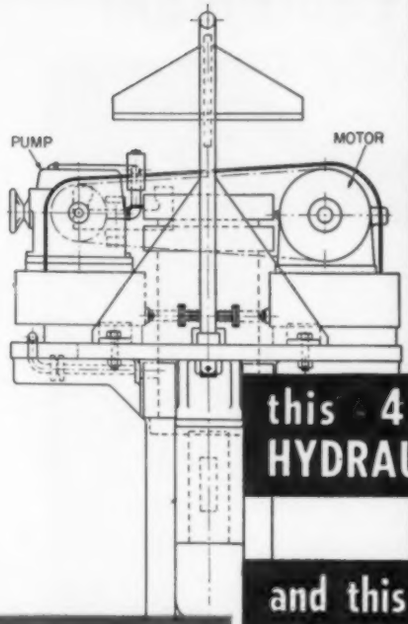

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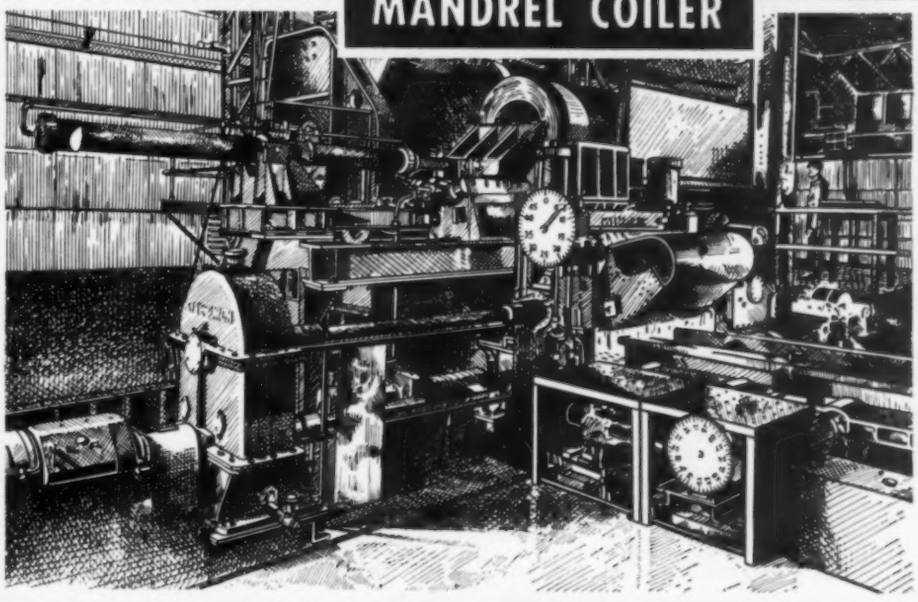

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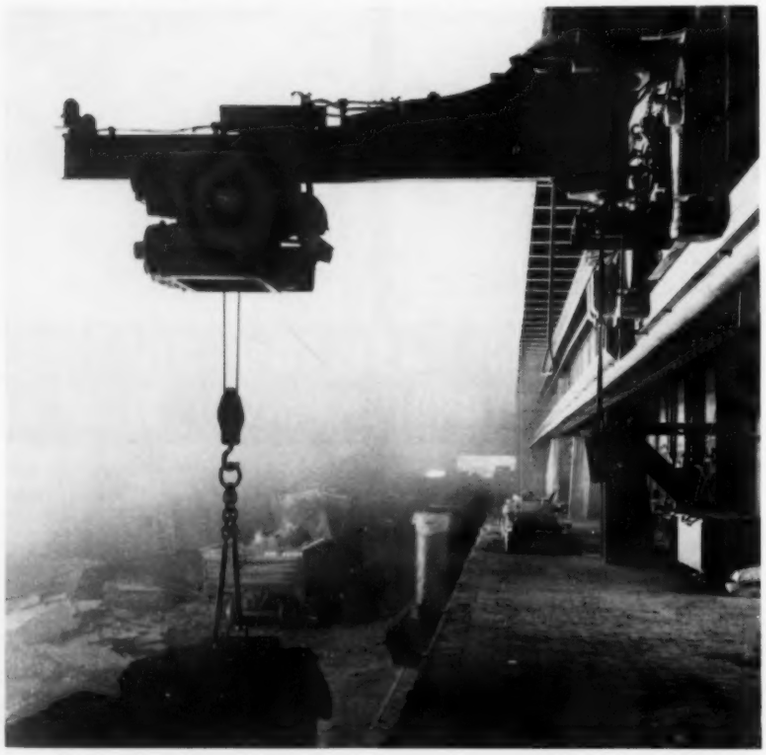

WALL TYPE capping crane showing steel mill application.

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And Other Special Steel Mill Equipment

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manufacturer. These new types of decals will resist an extensive list of commercial solvents and because of their unusual elasticity, will also resist unusual abrasion and accelerated weathering.

Type HR is a decal especially designed for application to laminated metal surfaces such as transformer cores, flexible shafts and casings. They are completely effective up to constant temperatures of 400 F. Type SHR is designed to withstand constant operating temperatures in the area of 500 to 600 degrees. One hour curing is considered adequate, although for resistance to unusual abrasion it is desirable to cure longer at higher temperature. Type HHR is a new development in decals that may be subjected to intermittent temperatures up to 1000 degrees without damaging effect. When cured at temperatures of 500 to 600 degrees, this decal will resist virtually any type of commonly used solvent.

Special adhesives and processes are not required since all three of these new decals are water immersed and hand applied.

LIQUID FLUX

▲ The development of a liquid flux especially formulated to make solder flow and hold on iron and steel as easily as on copper, bronze, zinc, etc., is announced by Industrial Craftsmen, Inc.

Without resorting to harsh chemicals, "Poly-Flux" thoroughly removes surface oxides. Tests indicate that joints soldered on iron and steel with "Poly-Flux" and solid solder with a regular soldering iron, or by the flame or dip methods are as strong as the solder itself.

GROUND DETECTOR

▲ A portable ground detector and fault locator for use on energized power lines, is now available in a universal model No. 54 from Parr Manufacturing Corp. By means of a voltage selector switch, this single instrument, the Brunt Faultfinder, may be used on power voltages of 120, 240, 480, or 550, ac or ungrounded dc, a feature which appeals to industrials who have systems of more than one voltage.

(*Please turn to page 316*)

BEST OF ALL HEAVY DUTY BONDING MORTARS

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SUPER #3000 Refractory Cement

The "Wonder Cement" for Resistance to High or Low Temperatures

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LASTS LONGER *under severe service*

For service to 3000° F., no refractory cement matches R. & I. Super #3000 for Bonding Strength — Hardness — Adhesiveness — Useful Life.

Reports from steel mills prove this plastic material, mixed with water and applied to make either thin or thick joints, has shown remarkable weld-tight resistance to shrinkage or spalling, abrasion and wear in blast furnace hearths and stack linings; soaking pit linings and covers; walls and arches of heating furnaces.

Used as a sealing wash coat, Super #3000 is practically impregnable, adding service life to existing refractories.

For hot patching, eroded or broken areas, it renews at low cost any refractory construction that would otherwise need complete replacement.

Everywhere Super #3000 shows definite improvement in lasting qualities over any bonding mortars previously used.

For greater furnace production, less maintenance and equipment downtime, it will pay you to use Super #3000. Write for details.

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Sturdy, rugged steel construction eliminates shock and vibration troubles.

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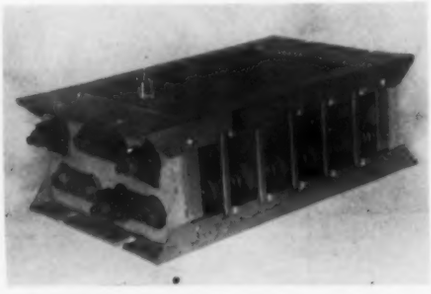

With a quarter century of resistor engineering, we invite you to take advantage of our experience.

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Buffalo, N.Y.—Buffalo Electric Co.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—H. V. Varney Co., 625 Engineers Bldg.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright

Pittsburgh 27, Pa.—P. R. Holden, 1602 Parkline Drive.

GUYAN MACHINERY COMPANY

LOGAN, W. VA.

(Continued from page 314)

Because it locates grounds on energized power lines, without interfering with continuous production, the faultfinder prevents costly shutdowns. In use, it transmits an audible signal over the faulted line, until the point of fault is reached, where the signal dies out. This signal enables it to be used in dark or inaccessible locations, and for tracing overhead or buried lines. An insulated extension pole makes ladder-climbing unnecessary.

Operated by one man, the faultfinder is rugged and durable, with no meters or instruments to adjust.

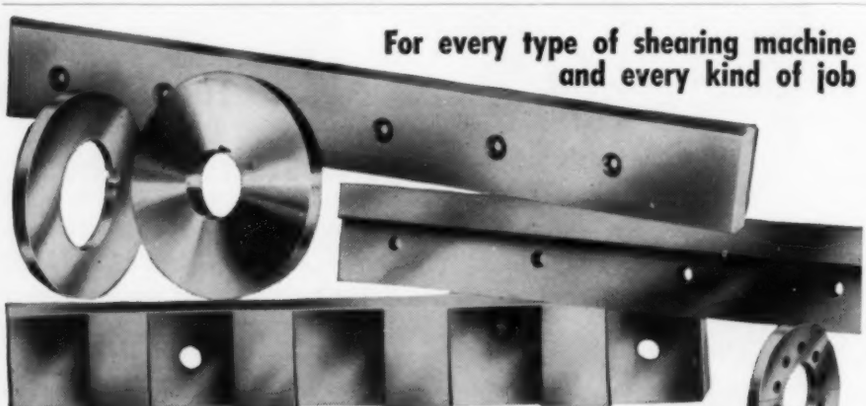
Book Reviews . . .

▲ **"The Cupola and Its Operation,"** the second edition of a 332-page technical book, was recently published. The revised edition is the work of the American Foundrymen's Society Cupola Research Committee.

Casebound, "The Cupola and Its Operation" contains 328 illustrations and 54 tables, plus a bibliography totaling 702 references. New material covers such late developments as hot blast, basic lining for nodular iron and emission control. Other chapters on refractories, principles of combustion, and metallurgy, if not presented for the first time, are greatly augmented by current additions. Selling for $9.50, the book is a ready reference for metallurgists, operating foundrymen and students of foundry technology. A special discount, enables members of the American Foundrymen's Society to purchase the new edition for $6.00.

▲ **"Temperature Measurements With Rayotubes,"** by Paul H. Dike was published by Leeds and Northrup Co., 4901 Stenton Avenue, Philadelphia 44, Pa. This 48-page monograph presents the history of radiation measurements, discusses the principles of radiation itself and of thermopiles and optical systems. It describes the various types of rayotubes, together with their standardization and calibration, and the actual measurement of temperatures with recorders in various industrial applications. Normally priced at $1.00, single copies will be sent without charge to those requesting them on their business letterheads from Leeds and Northrup Co. at the above address. This is a paper bound booklet measuring 10½ x 7¾-in.

For every type of shearing machine and every kind of job



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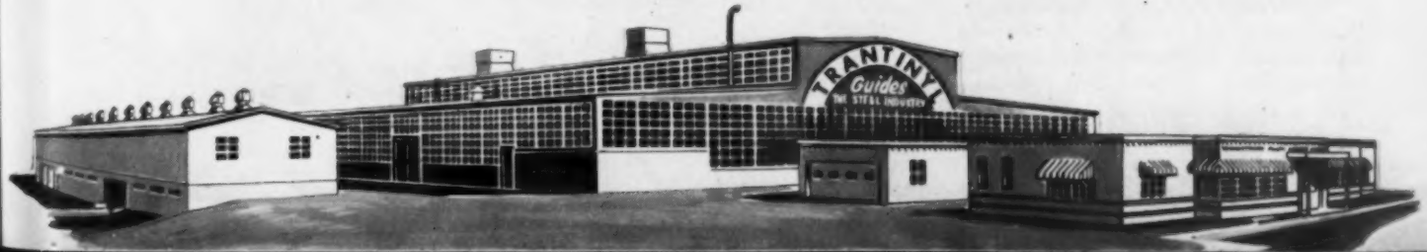

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PHOTOGRAPH BY RICHARD BEATTIE

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In so little time now, they must learn to live alone. For those they love will die: a year from now; a month from now; a few weeks, more or less. Only a merciful miracle can change the story: the final, sure *cure* for cancer. It is for this they pray.

And you are a part of their prayers. For man is the instrument of God's works. The miracle men pray for, in the battle with man's cruelest enemy, must come from the laboratories of men . . . the laboratories *you* support, through your contributions to the American Cancer Society.

You can turn the page now—and forget about the whole thing in twenty seconds. Or you can pause and consider how much *you* want to give.

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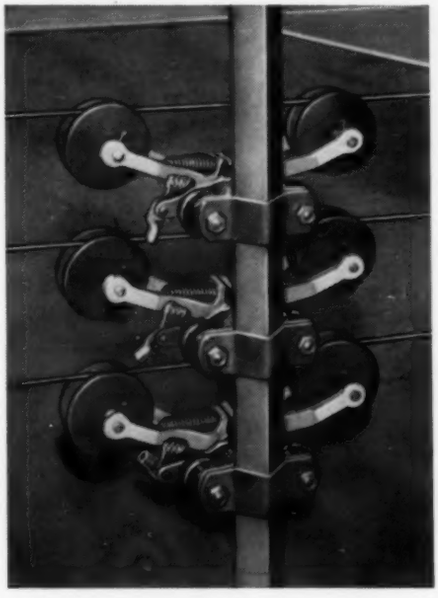

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with RED STREAK FLANGES save money in high speed snagging

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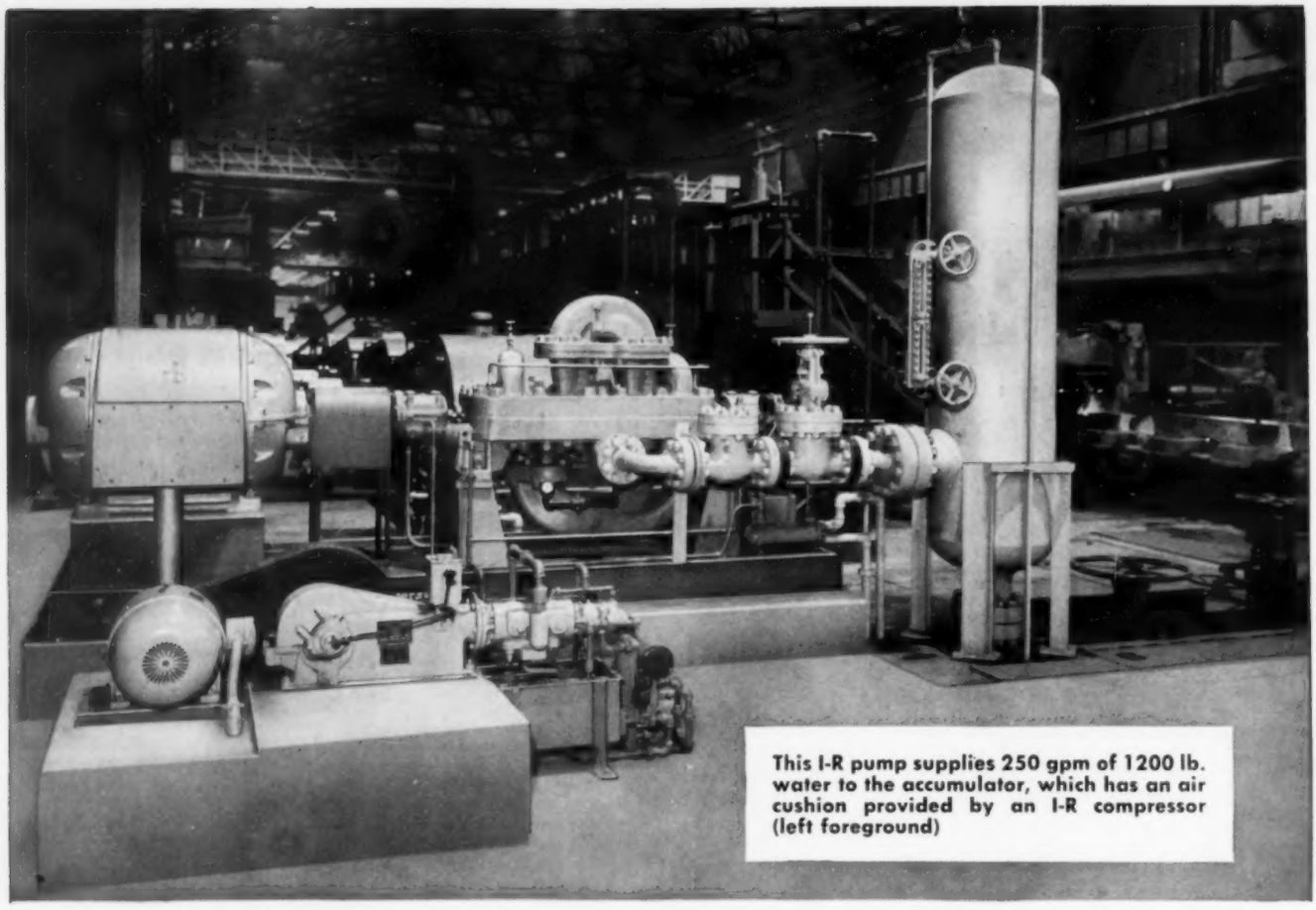

This I-R pump supplies 250 gpm of 1200 lb. water to the accumulator, which has an air cushion provided by an I-R compressor (left foreground)

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No. 154

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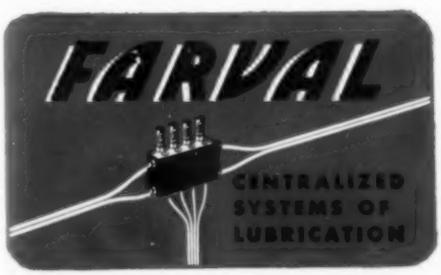

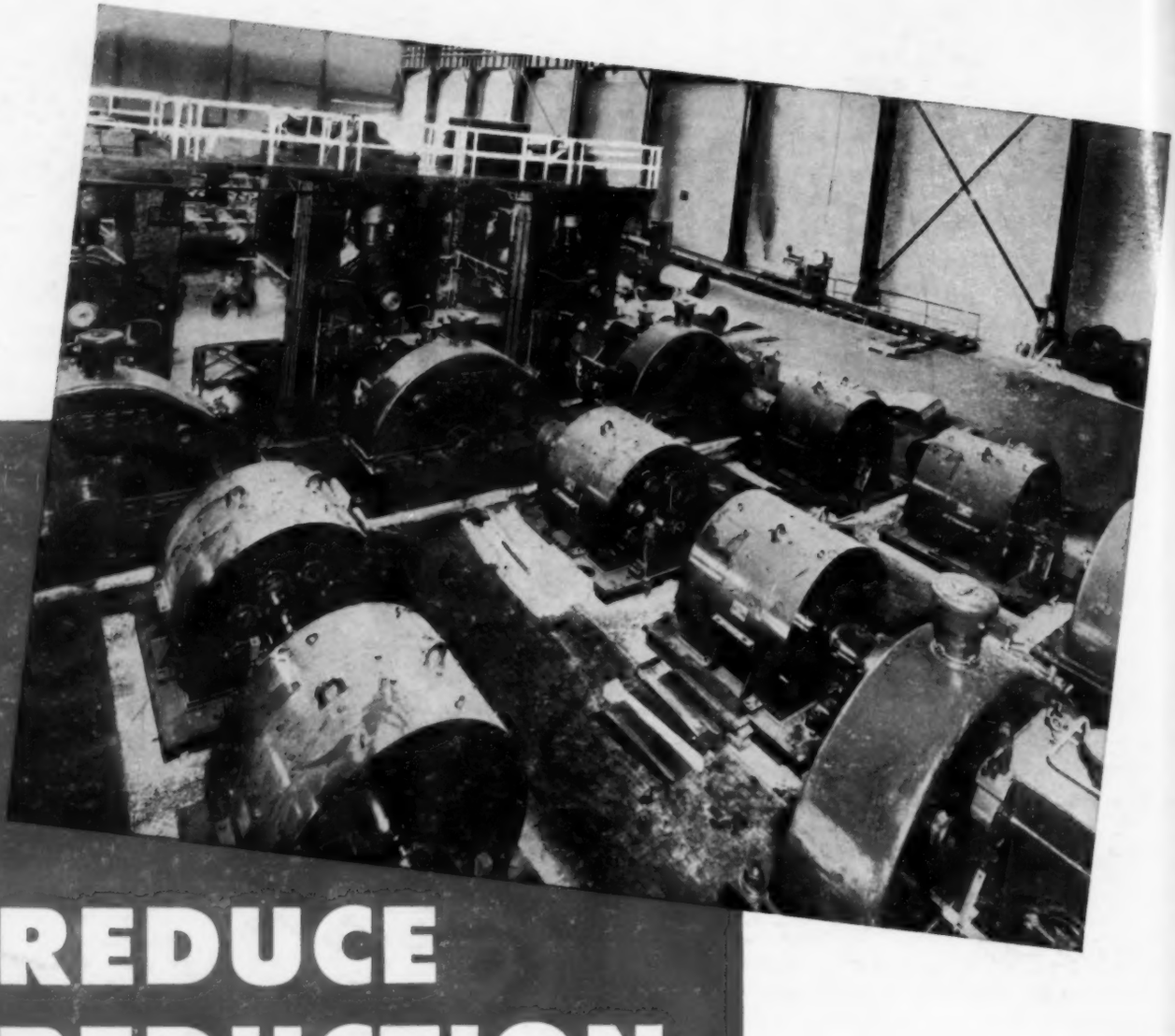

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